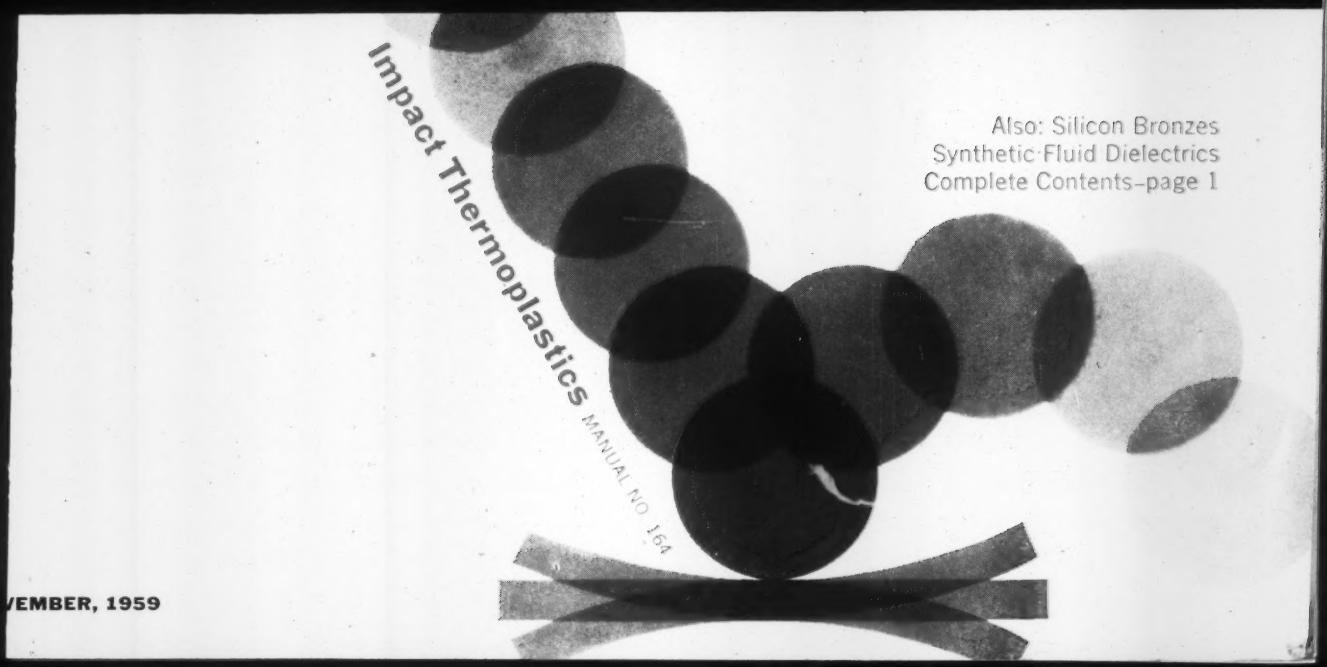
Materials in Design Engineering

FORMERLY

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES



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Synthetic Fluid Dielectrics
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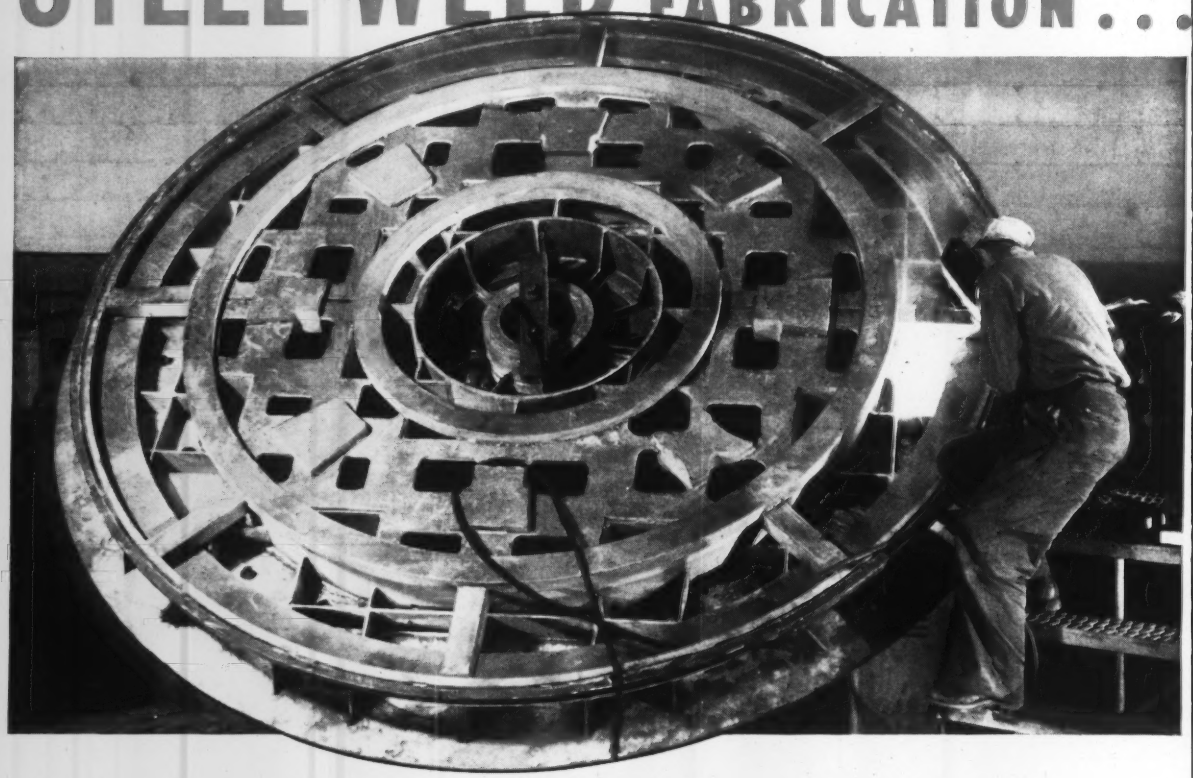
VEMBER, 1959

STEEL-WELD FABRICATION . . .



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Materials in Design Engineering, *formerly Materials & Methods*

Selection & use of metals, nonmetallics, forms, finishes

NOVEMBER 1959
VOL. 50, NO. 6

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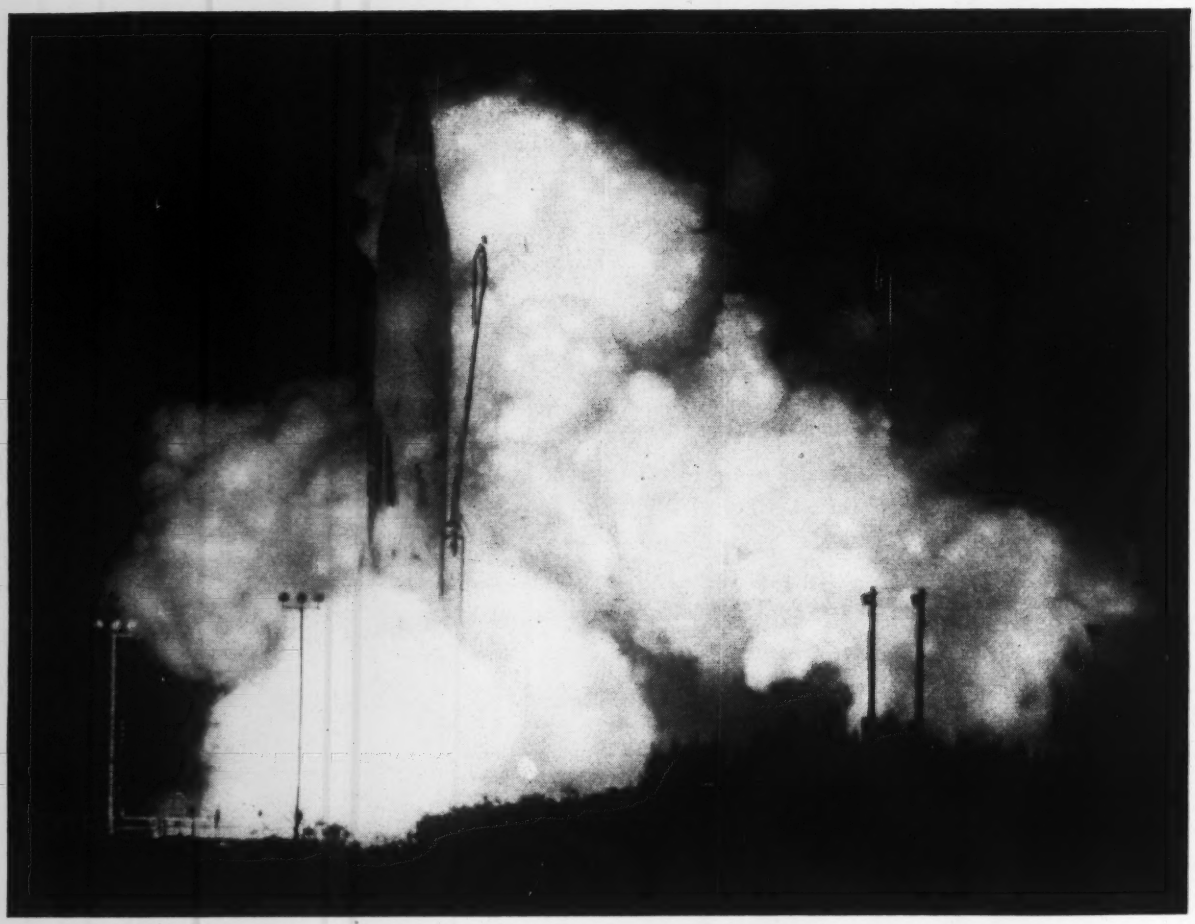

Record breaking Atlas missile billows flame and vapor as she launches 4¼-ton satellite into orbit. Constructed of Type 301 Nickel Stainless Steel, Atlas is built by Convair (Astronautics) Division of General Dynamics Corporation. *U.S. Air Force photo*

130 tons of missile with a skin thinner than a window pane!

The Nickel Stainless Steel skin of the Atlas missile is actually about one-third as thick as the glass in your window.

And yet look what this skin does:

- It is the sole structural framework for Atlas—130 tons of dead weight at the moment of firing.
- It serves as the wall of the propellant tanks in Atlas' weight-saving design.
- It withstands the deep chill of liquid oxygen (−297°F) . . . the high heat of supersonic speed (400°F–600°F).

. . . And it is less than 1/25 of an inch thick!

No wonder they call stainless the space age metal. No wonder engineers turn more and more to Nickel Stainless Steel as temperatures rise . . . as speeds soar . . . as demands get more and more severe.

But Nickel Stainless Steel has many earthbound applications, too. Its strength and resistance to both corrosion and temperature extremes improves the performance and prolongs the life of many industrial products. And its attractive appearance provides still another reason for its popularity in products for the home.

What's your metal problem? Is it high or low temperatures? Corrosion, stress, fatigue or an unusual combination of factors? Write to us about it. Perhaps Nickel—or one of its alloys—can help you get it off the ground.

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What's new IN MATERIALS

...AT A GLANCE

New ICBM nose cone of nylon-phenolic seems likely from released data. Successfully tested in early October, the new Atlas Mark III cone is designed for high speed reentry, generating temperatures of 12,000 F upwards. At such temperatures organic-reinforced phenolics ablate at rates lower than inorganic-reinforced phenolics, according to earlier published data (see M/DE, June '58, p 102).

Source: Haveg Industries, Inc., 900 Greenbank Rd., Wilmington 8, Del.

A high strength titanium alloy is said to have far better strength, ductility and toughness than any titanium alloy now commercially available. A 1-in. dia forged bar exhibits 200,000 psi tensile strength, 187,000 psi yield strength (0.1% offset), 5% elongation, and 25% reduction in area. (More details next month.)

Sources: H. Margolin, College of Engineering, New York University, University Heights, New York 53, and Watertown Arsenal, Watertown, Mass.

Paint pigmented with stainless steel has been developed for use on exposed steel and aged galvanized iron. Outstanding advantages are: extreme durability in corrosive atmospheres, life expectancy of at least 12 years, very smooth surface, and excellent hiding properties. (More details next month.)

Source: Vita-Var Corp., 10 Commerce St., Newark 2, N. J.

A structural foam plastic, now in experimental stages, looks promising as a high strength sandwich core material. Foamed to 2-20 lb per cu ft from a furane-base resin, the material is similar in properties to phenolic foam, but is said to be less frangible. Aimed at the 20-40¢ per lb price range, experimental samples meet requirements of MIL-C-8087. Developmental quantities will be available in 4 to 6 months.

Source: U. S. Stoneware Co., P. O. Box 350, Akron 9, Ohio.

Improved thin-film electronic components are promised as a result of newly developed chromium-titanium nitride, chromium-silicon and indium oxide films. The materials are said to complement and extend advantages provided by existing films now used as resistors, potentiometers, photoconductors, resistance thermometers and windshield heaters.

Source: E. H. Layer, Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio.

A radiation-resistant epoxy coating has been developed and is now being used as a protective coating on a nuclear reactor. Tests show that panels coated with the material suffered no visible damage, i.e., cracking, flaking, bubbling or blistering, after 4 1/2 hr exposure to 1×10^9 roentgens. The two-part coating also withstood over 9500 hr of attack by boiling water, jet fuel and salt spray. (More details in a forthcoming issue.)

Source: Shell Chemical Corp., 50 W. 50th St., New York 20.

Pinhole-free FEP fluorocarbon film will be available for the first time in commercial quantities late this year. It will sell for $15 per lb, and will be supplied in

thicknesses ranging from 1/2 mil to 40 mils and over. The film is heat sealable, vacuum and heat formable, can be metallized, and in many instances can be bonded to other materials without adhesives. It has excellent electrical characteristics and is inert to virtually all known chemicals and solvents at temperatures up to 400 F. (More details next month.)

Source: E. I. du Pont de Nemours & Co., Inc., Film Dept., Wilmington 98, Del.

High quality, low cost spot welds can be obtained by using a new resistance welding feedback control. The control uses computer circuits and data processing techniques to overcome such obstacles to weld quality as line voltage fluctuation, electrode wear, variations in electrode tip force, surface finish and shunting. (More details in a forthcoming issue.)

Source: Budd Co., Electronic Controls Section, Philadelphia 32.

A method for chemical milling honeycomb cores promises potential savings of millions of dollars in aircraft and missile production. The process, applicable to aluminum and steel cores, works by: 1) pressing a block of honeycomb core into a plaster-like, water dispersible "negative" representing the reverse side of the desired contour, 2) masking the exposed portion of the honeycomb cells, 3) dissolving the negative, and 4) removing the unmasked portion of the honeycomb by chemical milling.

Sources: Norair Div., Northrop Corp., 1001 E. Broadway, Hawthorne, Calif. and Chem-Mill Div., Turco Products, Inc., Wilmington, Calif.

A new heat treating process claims to improve the mechanical properties of any metal that can be heat treated. Yield strength is increased as much as 35% in some cases, with no degradation of ductility as measured by per cent elongation. Improvement is claimed to result from formation of equiaxed, uniform grains after heat treating. (More details next month.)

Source: Research Development Corp. of America, Gardena, Calif.

Aircraft-quality beryllium extrusions will be available in popular sizes and shapes in less than two years, a major designer and producer of space vehicles predicts. Tests show the metal can be extruded by techniques similar to those used for steel. Glass powder seems to be the best lubricant, and cobalt-chromium alloy dies seem to hold up better than other dies. Experimental extrusions have tensile strength of 80,700 psi, yield strength of 54,100 psi, and elongation of 3.5 to 6%.

Source: J. A. VanHamersveld, Norair Div., Northrop Corp., 1001 E. Broadway, Hawthorne, Calif.

A fast, simple method for bonding TFE resin to itself and to other materials has been developed. Basis of the new system is an activated form of sodium in solution which reacts with TFE resin to form a carbonaceous film on the treated surface. The carbonaceous film is compatible with epoxy, phenolic, and most rubber and silicone adhesives.

Source: W. L. Gore & Asso., Inc., 487 Papermill Rd., Newark, Del.

A new aluminum alloy sheet may compete with galvanized sheet in a number of applications. The aluminum sheet, fabricated from a new alloy, is priced about the same as galvanized, and is supplied in a broad range of widths and gages.

Source: Aluminum Co. of America, 1901 Alcoa Bldg., Pittsburgh 19.

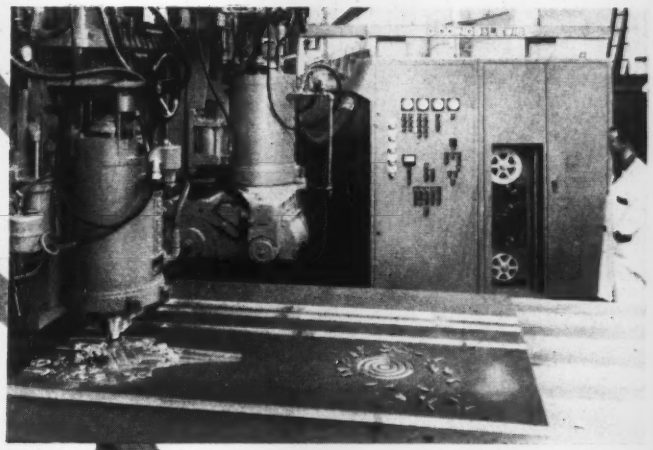
Turn to page 143 for more "What's New in Materials"

News about

B.F.Goodrich Chemical *raw materials*

Hycar helps insure accuracy of machine's

MAGNETIC MEMORY



Numericord System *made by Giddings & Lewis Machine Tool Company, Fond du Lac, Wisconsin, uses magnetic tape playback (seen through glass door in controller in photo) with tape manufactured by Reeves Soundcraft Corporation, Danbury, Connecticut. B.F.Goodrich Chemical Company supplies the Hycar polyacrylic rubber used in bonding metallic particles to tape.*

Profitable use of this machine tool automation system's "store of skills" depends on precision manufacture of tape to which magnetic particles are bonded with Hycar polyacrylic rubber. The tape stores and transmits design information which can be used to program a number of machines for mass production. Or stored tapes can replace a finished parts stock by providing fast, accurate reproduction of parts from blanks.

Magnetic particles have to be bonded uniformly over tape length to precise thickness. Hycar was selected for its stability, excellent adhesion and good binding qualities. Since tapes undergo frequent use and often have to be stored for long periods, the long wearing and good aging characteristics of Hycar are also important.

Here's another example of the way Hycar helps improve a product or makes possible new applications. Get more information by writing Dept. CL-5, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

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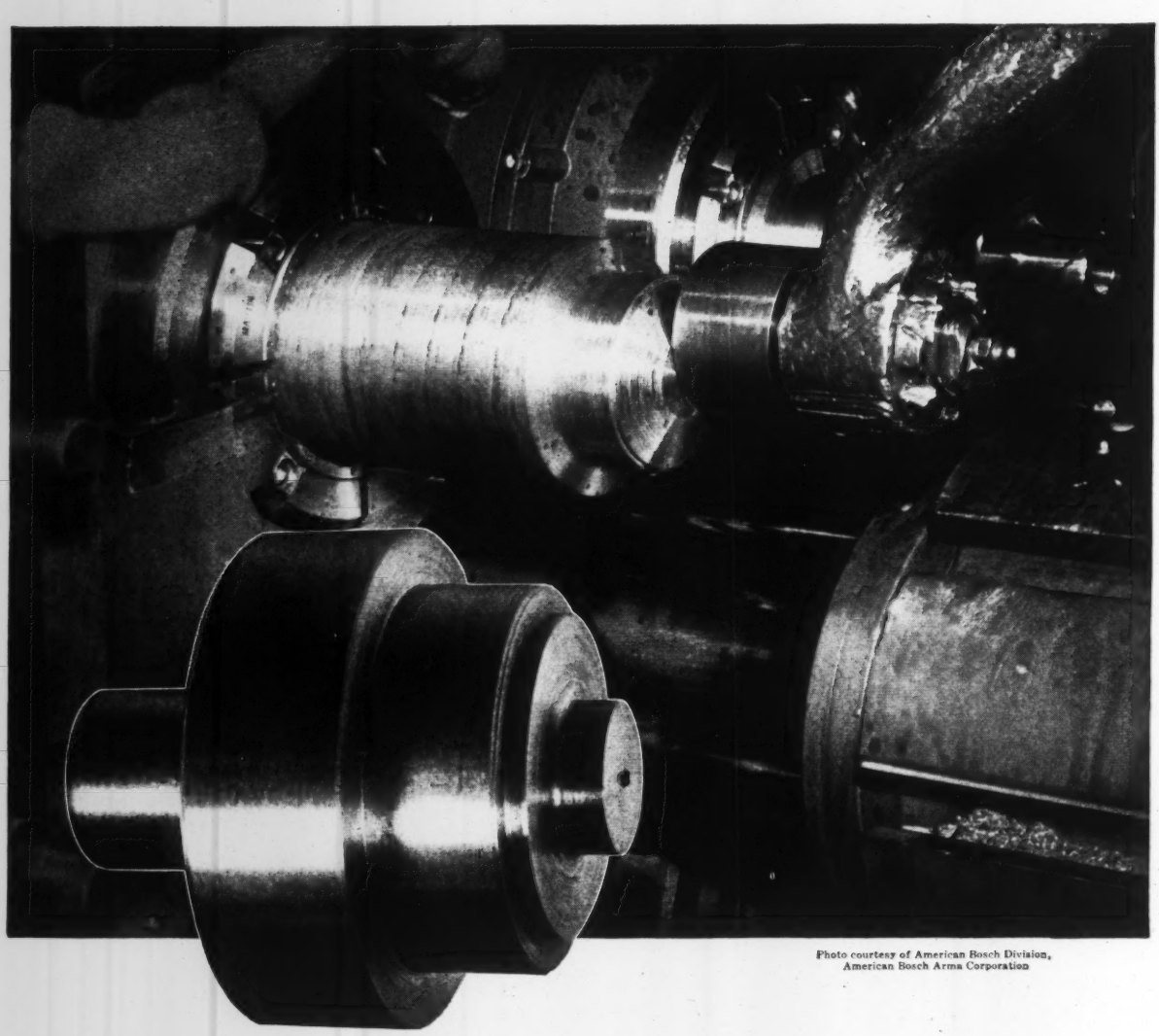

Photo courtesy of American Bosch Division,
American Bosch Arma Corporation

Leaded Nitralloy Takes a Big Bite Out of Machining Time!

By switching to Nitralloy Leaded for this hydraulic head, secondary lathe operations and expensive heat treatment were completely eliminated. Produced in a single machining operation, the part is now sent directly to the grinding department. Spindle speeds and feeds were also increased.

For complete information about other fast-machining Aristoloy leaded steels or standard carbon, alloy and stainless grades, call the Copperweld representative in your nearest large city. Or write for booklet entitled, "A Complete Line of Leaded Steels," and NEW PRODUCTS & FACILITIES CATALOG.

ARISTOLOY STEELS

COPPERWELD STEEL COMPANY

ARISTOLOY STEEL DIVISION • 4021 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

For more information, turn to Reader Service card, circle No. 491

MATERIALS AT WORK

...AT A GLANCE

Aluminum air conditioner coils reaccepted

All-aluminum coils are now being accepted for use in air conditioners. When first introduced in 1950, the aluminum coils proved inadequate for some corrosive conditions and air conditioner manufacturers shelved the entire idea. However, the development of new alloys and new soldering techniques (zinc soldering), plus aluminum's traditional advantages of light weight and low cost (as compared to copper coils), has led to renewed interest in its use for this application. Exhaustive tests conducted on Alclad aluminum alloy, for example, indicate that aluminum can be used successfully not only for coils, but for other parts of air conditioners as well.

Source: Aluminum Co. of America.

Molded acetal used in redesigned fishing reel

Molded acetal (Du Pont's new thermoplastic) is being used for the main parts of a redesigned spinning reel. Reasons given for the selection of acetal: low moisture absorption, good toughness, low coefficient of friction and high rigidity. Parts made of acetal are front and back covers, body, thumb stop, drag adjustment wheel, anti-reverse wheel, and pick-up pin retainer.

Source: Continental Plastics of Oklahoma

Hard surfacing of worn valves saves $2 million

The use of hard surfacing to reclaim worn and eroded stainless steel exhaust valves has saved the Navy almost $2 million over the past three years. Previously, valves were scrapped after one service tour; now the worn valves are simply sprayed with a nickel-base alloy containing chromium borides and carbides and put back into service. The protective coating, which is 0.005-0.007 in. thick, is said to be more abrasion resistant than hardened stainless steel.

Miniature casting replaces screw machine part

The switch from a screw machine part to a precision miniature casting has resulted in a two-thirds reduction in the cost of a tiny power shaft used to control the shutter speed and timing mechanism in 35-mm cameras. Previously, the part required extensive milling and other costly and time consuming secondary operations. Now, the part, which is about 0.5 in. long, is cast from a tough chromium-nickel-molybdenum steel with tolerances held to ±0.002-0.005 in. The only secondary operations required are simple drilling and shaving of teeth.

Source: Casting Engineers, Inc.

Steel and PVC combined in unique pipe

A special type of steel-jacketed polyvinyl chloride pipe has solved a difficult problem in the design of a piping system used to carry a 0.05% chlorine solution. Because the chlorine solution was to be fed through the 2-in. pipe at infrequent intervals, and there were no facilities for purging the line, corrosion resistant PVC was specified instead of steel. However, the 2-in. pipe was not strong enough to span the 22-ft spaces between support trusses of an existing pipe bridge. By bonding the PVC pipe to

(continued on p 9)

Briefs

Anodized aluminum sun dials are said to be more accurate than electric clocks. The dials are pre-set at the factory for longitude and latitude at which they are to be used and are easily adjusted for daylight or standard time. Cloudy days may prove troublesome however.

Plastics golf club heads may eliminate slicing. Here's how: moisture absorbed from the air causes distortion in wooden club heads; 1 deg of misalignment, for example, will make a perfectly stroked ball veer off 40 ft in a 225-yd drive. The molded plastics heads are said to be completely moisture-proof and more durable.

Stainless steel sinks will be used in about 7 out of 10 new homes by 1970, according to a recent survey.

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These tiny zinc die cast electrical contact socket cups have a minimum wall thickness of .005″— **the thinnest wall section ever die cast.** Designed by Omaton Division of BURNDY CORPORATION, they more than meet Government specifications and are adaptable for many types of solderless multi-contact connectors.

It takes 10,371 of the smallest cups to weigh a pound and they are 20% lighter than the ones formerly made from drawn steel. Each is precision die cast to a remarkable degree of uniformity and accuracy, despite the complex design.

Such extremely thin-wall sections—possible only with zinc die castings—**frequently eliminate competition from all other materials and production methods.** In addition, ZAMAK zinc die castings provide many more advantages —and all at lower cost.

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THE NEW JERSEY ZINC COMPANY

DEVELOPERS OF THE ONLY STANDARD ZINC DIE CASTING ALLOYS IN USE TODAY

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the interior of a carbon steel jacket, requirements of both strength and corrosion resistance were satisfied.

Source: Jones & Laughlin Steel Corp.; used by Texaco, Inc.

Teflon bobbin specified for missile relays

Longer and more positive operation are the advantages claimed for the use of Teflon coil bobbins in microminiature missile relays. Teflon was selected because it satisfied the following requirements: resistance to temperature changes from –85 to 250 F; ability to withstand 100,000 operations of the relay; ability to switch loads up to 2 amp; and resistance to shock loads up to 150 g's. The bobbins, which measure 0.3 in. in dia and 0.4 in. long, are machined with tolerances held to ±0.001 in.

Source: Tri-Point Plastics Inc.; Teflon supplied by Du Pont; relays manufactured by Filtors, Inc.

Honeycomb structures reduce aircraft weight

Because honeycomb structures provide high strength-to-weight ratios and good resistance to sonic damage, they are being specified in increasing quantities for advanced space craft. One of the newest jet airliners, the Douglas DC-8, makes extensive use of two types —aluminum for wing and tail sections, and glass fabric for antenna windows. Honeycomb was selected for the basic structure of the recently-launched Pioneer I satellite and will be used extensively in the Mercury space capsule which is expected to put a man into space next year.

Source: Hexcel Products, Inc.

Galvanized steel fences for SAC bases

Galvanized steel has been selected by the Air Force for a system of concave fences scheduled to be erected around taxiways and runup areas at 26 Strategic Air Command jet bases in the United States and Puerto Rico. The fences will be used to deflect the high-velocity hot blast from the jet engines upward into the air and thus protect personnel and prevent fires. Galvanized steel sheet was selected because of its strength and fire resistance qualities.

Source: Committee on Galvanized Steel Sheet Research; fences supplied by Vinnell Steel Co.

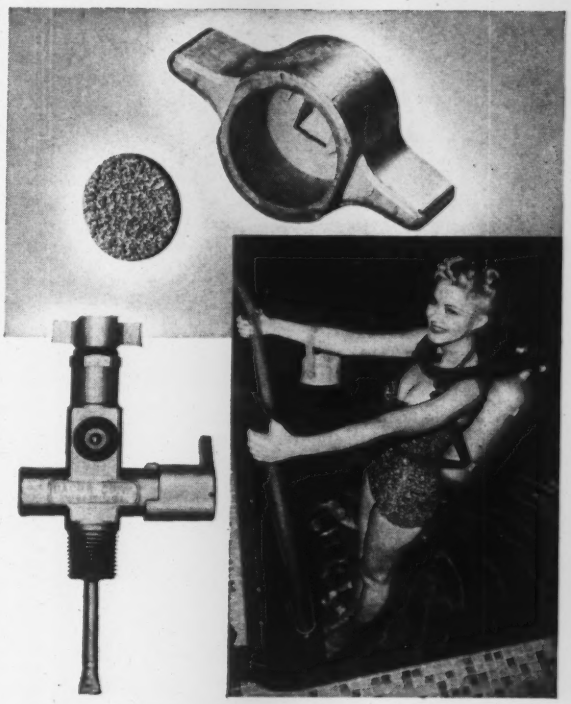
Aluminum trailers carry sugar

A weight saving of nearly 5500 lb has been achieved by the switch from steel to aluminum for trailers used to transport bulk sugar. The trailers, made of alloy 5086, weigh only 13,670 lb, as compared to 19,000 lb for similar steel trailers. A second advantage claimed for the use of aluminum is the elimination of periodic sand blasting and recoating.

Source: Kaiser Aluminum & Chemical Corp.; trailer fabricated by Clough Equipment Co.; used by U & I Sugar Co.

(more Materials at Work on next page)

ADVANTAGES SUCH AS THESE with ***METAL POWDERS***



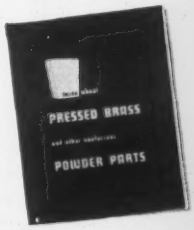
PROVIDE DEPENDABLE NON-CORROSIVE PARTS FOR THE ***DACOR*** DIVING LUNG

The control knob* for DACOR CORPORATION'S reserve valve was designed for the powder metallurgy process—made in both NICKEL SILVER and BRASS metal powders.

The air filter is also a sintering, in BRASS powder, costing 30% less and providing better filtering action, than the former one made with layers of brass screen cloth.

Only NONFERROUS POWDER METALLURGY can provide these parts at low cost—ready for assembly with a bright, lasting finish without plating.

*by Parker White Metal Company, Erie, Pa.



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will assist you in evaluating this modern production method in terms of your particular needs.

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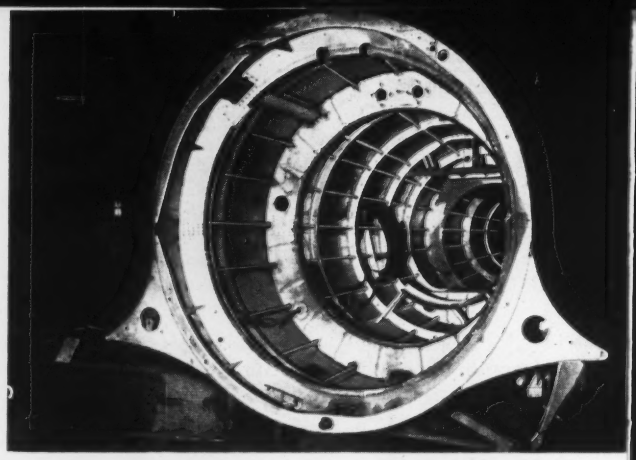
For more information, turn to Reader Service card, circle No 374

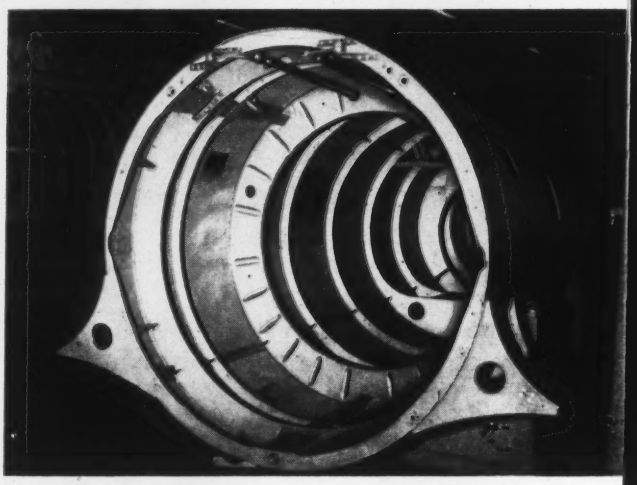
Edited by
Walter Lubars

MATERIALS
AT WORK

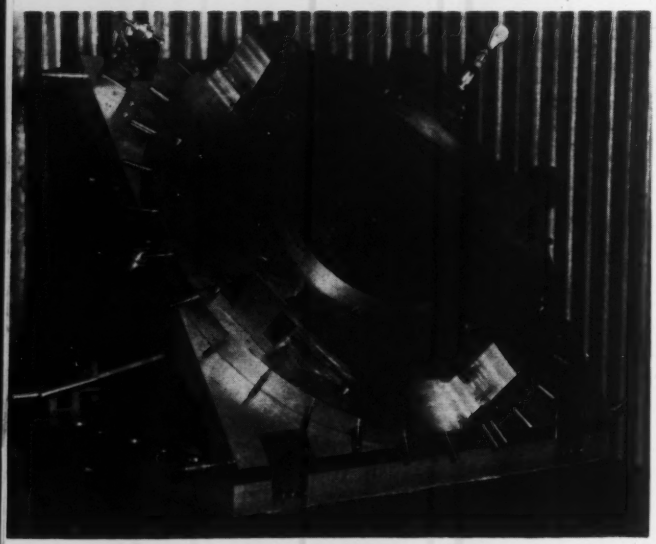
Magnesium cuts weight, improves design

Thanks to the development of new alloys, new fabrication techniques and new finishing systems, today's magnesium alloys are being easily and successfully used for many applications considered impossible 20 years ago. The accompanying photos, furnished by the Magnesium Assn., show some examples of the wide variety of applications and fabrication techniques for which magnesium alloys are suited.



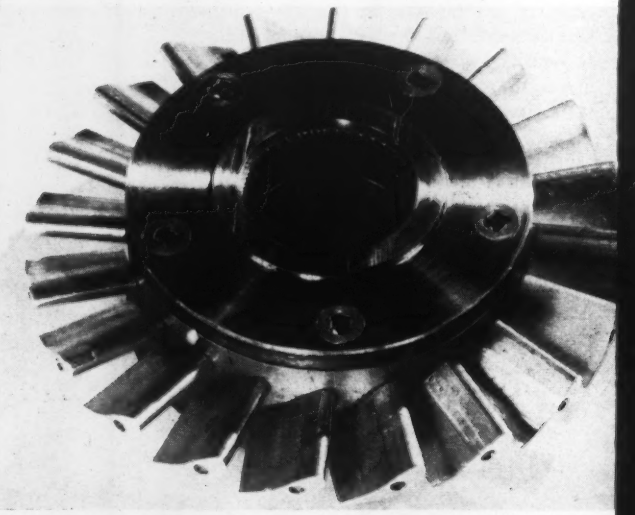


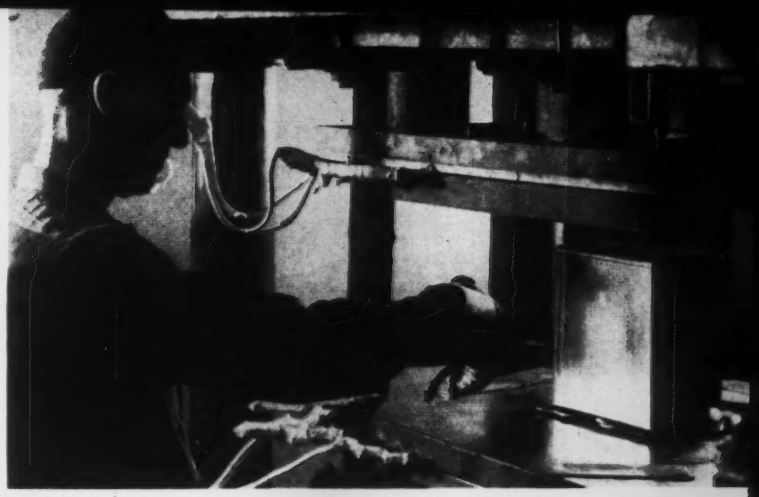
Aft-fuselage assembly *shown just above takes advantage of magnesium's light weight to increase sheet thickness and thereby eliminate many stringers previously required with aluminum (top photo). In addition to reducing manufacturing time and assembly operations, the magnesium unit provides improved torsional rigidity and considerably smoother aerodynamic surfaces. It is estimated that 35% fewer parts and fasteners are used in the redesigned unit.*



Indexing sine plate fixture *made of 1½-in. thick magnesium tooling plate weighs 180 lb; when made of steel it weighed 708 lb. Other advantages: increased production at less cost as a result of magnesium's excellent machinability and stability.*

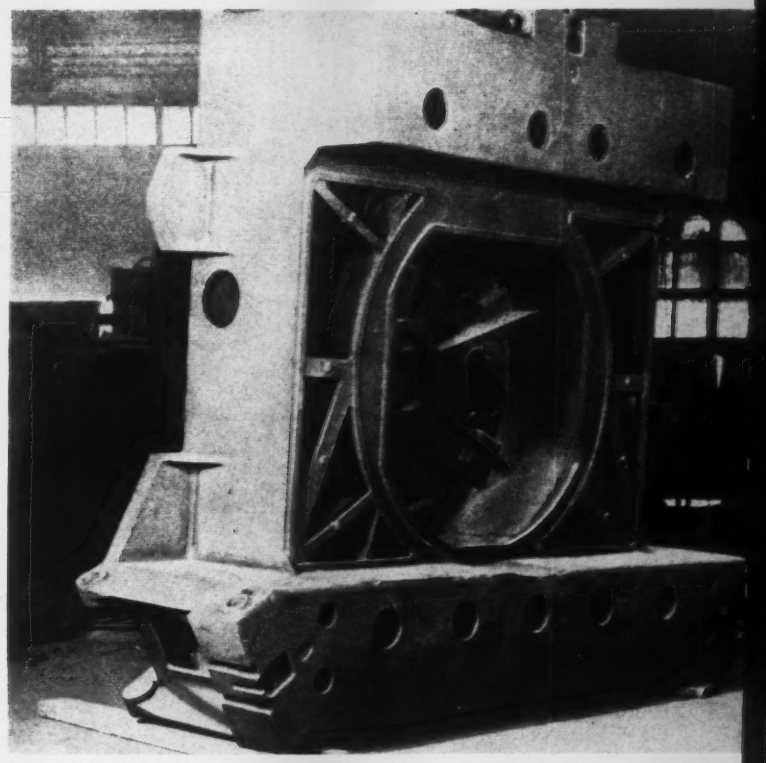
Extruded blades *were specified for the variable pitch stator used in Chevrolet transmissions because the previously used aluminum blades slowed production. Originally, a 5/32-in. hole had to be drilled in each blade. Now, the hole is extruded in with tolerances held to ±0.004 in.*





Housing *for portable Signal Corps telephone equipment is 10 in. deep, 9 in. long and 6 in. wide—yet it was drawn with one die in one stroke with tolerances held to within ±0.005 in. at the trim line. The various latches, brackets, etc. are either welded or riveted.*

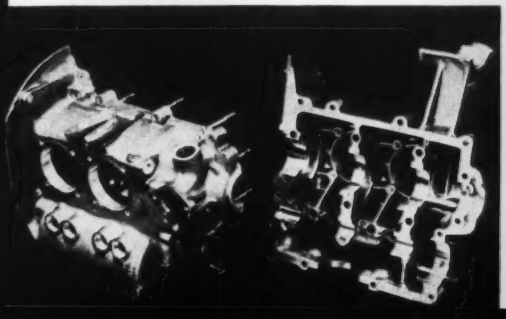
Zero draft forgings *are replacing conventional magnesium forgings for spars used in F-101A jet planes because they provide: a reduction in premachined weight from 122 to 39 lb; less machining time; and superior structural strength as a result of the natural grain flow pattern in the finished part.*



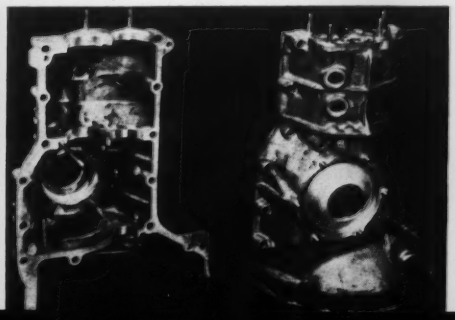
Sand cast base *for Nike missile is the largest magnesium casting made to date—it weighs more than 1600 lb. Magnesium was selected for its excellent damping capacity and because any other material would have made weight excessive.*

Die castings *are now being specified for automobile parts because they are easy to produce and machine, and provide considerable weight savings. (In addition to the well-known German Volkswagen, several other European auto companies are now said to be using magnesium die castings.) The lightweight crankcase and transmission housing shown below consist of matched castings which are simply assembled together.*

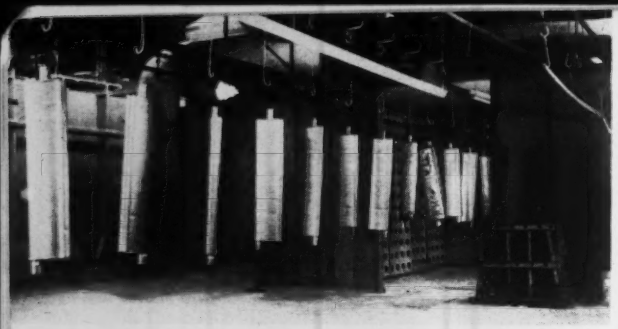
Crankcase—20.5 lb



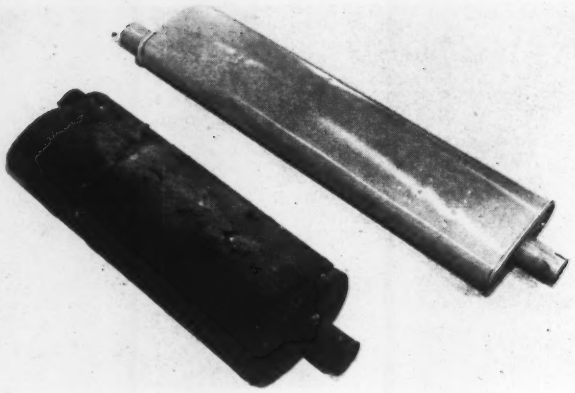
Transmission housing—13.5 lb



Volkswagen



Special dipping technique *produces ceramic-coated steel muffler that . . .*



. . . wears longer *than conventional mufflers (coated muffler shows no sign of corrosion after equivalent of 25,000 miles of operation).*

Ceramic-coated mufflers will last 100,000 miles

Automobile mufflers that won't burn out or corrode even after 100,000 miles of service are now said to be practical—thanks to a new ceramic coating technique.

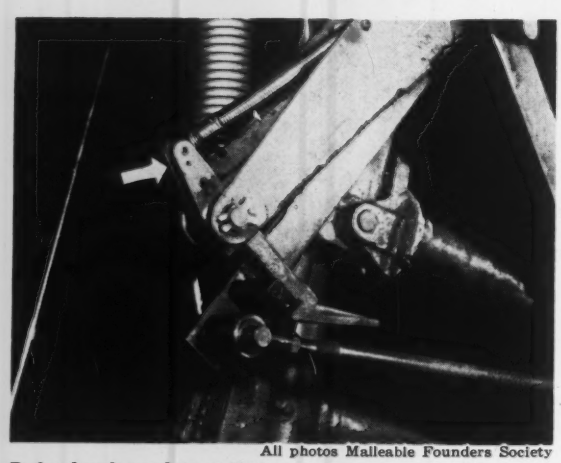
According to Bettinger Corp., the idea of coating mufflers is not new: the company has been successfully coating straight truck mufflers for some time. The difficulty lay in the impossibility of coating all possible corrosion spots in the highly convoluted tubes and chambers of today's complex mufflers.

The secrets of Bettinger's new process are 1) a slight change in the previously used ceramic formulation and 2) special dipping equipment which insures that all parts are evenly coated (no details revealed on either innovation).

In the coating process, a 0.003-0.004-in. thick skin of ceramic is fused at very high temperatures into the inside and outside surfaces of the alloy steel muffler. The whole process, from preliminary cleaning to final firing takes about an hour.

According to Bettinger, the ceramic-coated muffler will cost about the same as presently available premium-priced mufflers, but will last twice as long.

Malleable castings simplify redesigned pinsetter



All photos Malleable Founders Society

Rake hook *used to pull the sweep arm across the bowling alley for removal of fallen pins. This part was shell molded of malleable iron to provide close tolerances and to reduce machining requirements. In addition, malleable's non-galling characteristics made it possible to eliminate bushings. The hook is subjected to heavy loads caused by leverage action of the sweep mechanism.*

The accompanying photos show some of the 46 malleable castings (produced by nine different foundries) which contributed to the efficient, inexpensive automatic pinsetter redesigned by Brunswick-Balke-Collender Co.

Most important properties of malleable iron castings are: high toughness and ductility, good resistance to atmospheric corrosion, excellent machinability, and ease of casting in a wide range of sizes and shapes.

(other parts shown on p 201)

MORE MATERIALS AT WORK

Welded polypropylene for tanks, liners 201

Tantalum heaters prove most efficient 204

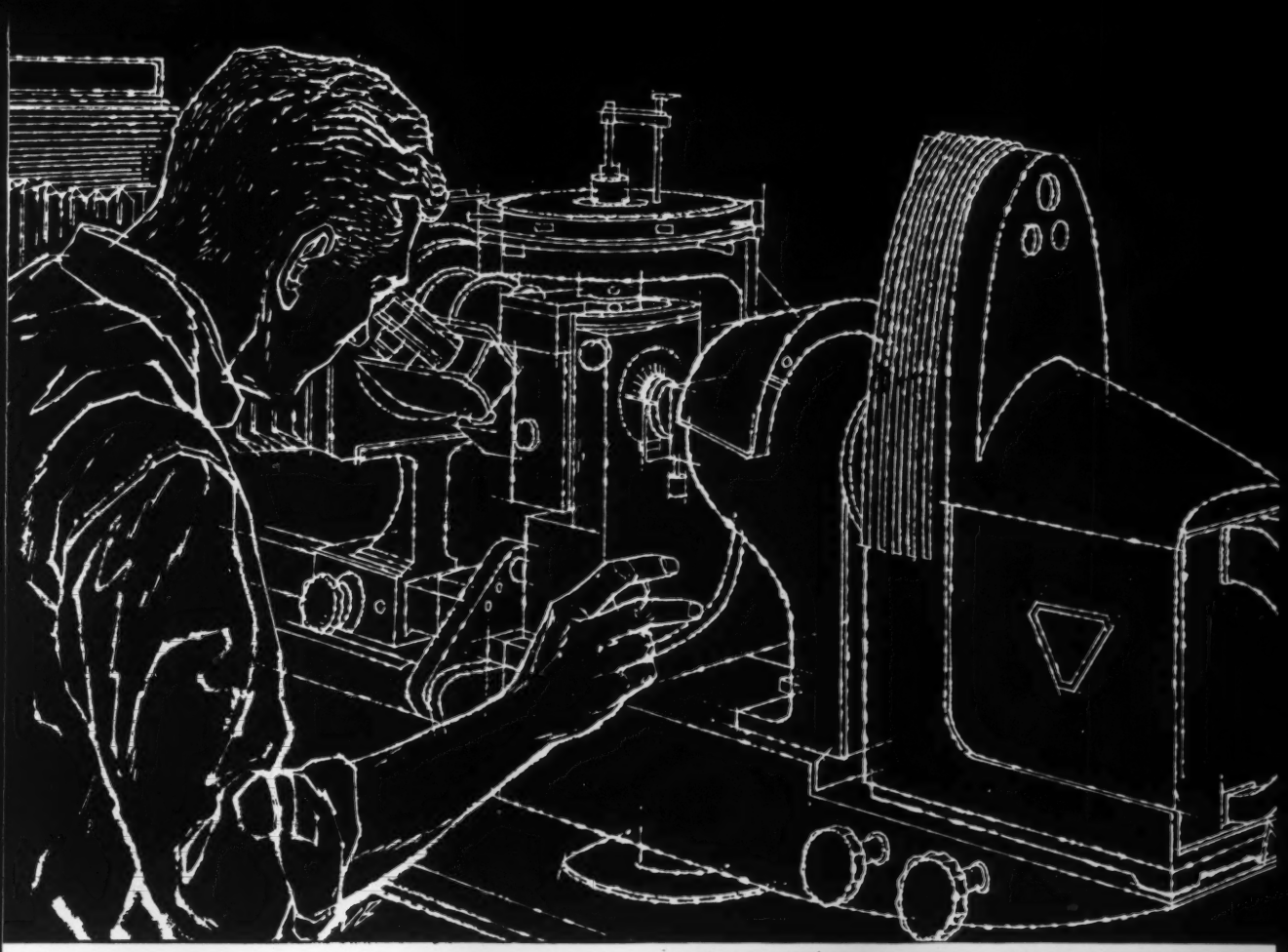
Cast epoxy mirror better than glass..... 206

Largest titanium ring used in space capsule..... 209

Reinforced plastic insulates bus bar 210

Aluminum tubing cools concrete dam 212

Nylon replaces metal in machine tools 214



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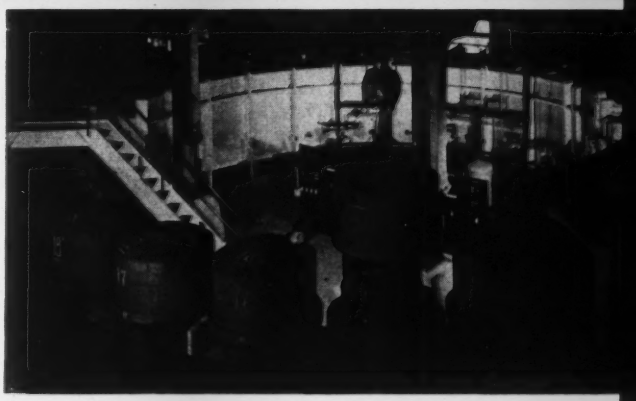
For your convenience, precision strip facilities are available to you in our plants at Youngstown, Indianapolis, Los Angeles and Kenilworth (N. J.)



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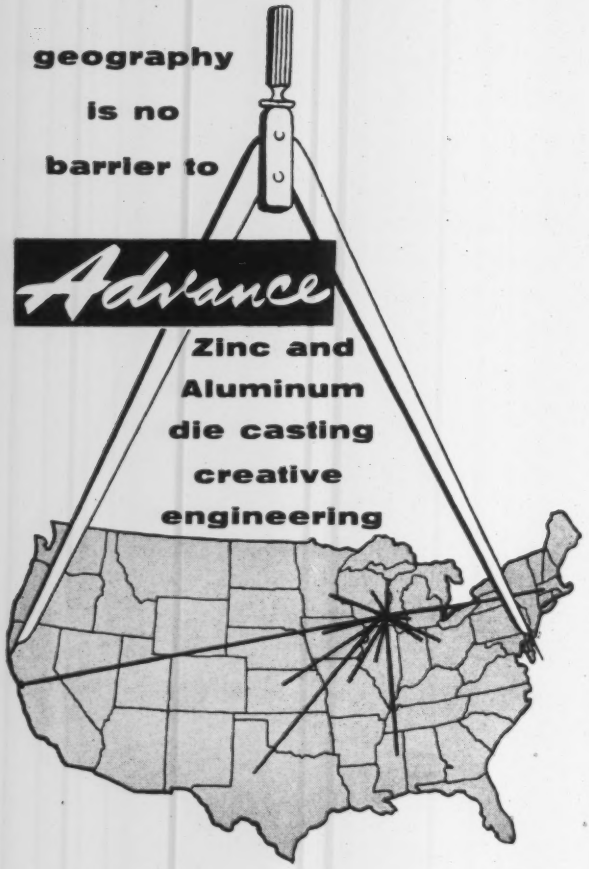

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Aluminum coating process questioned . . .

To the Editor:

The article "New High-Purity Aluminum Coatings," Feb '59, p 88, interested us because of our background on aluminum plating. The article shows that North American Aviation uses the aluminum process developed at the National Bureau of Standards, which was described in a paper by Brenner and Couch, *Jnl. of the Electrochemical Soc.*, Vol. 99, '52. Electroforming waveguides of aluminum was first described by Safranek, Schickner and Faust in the same volume. Their waveguides had a much smoother outer surface than that pictured on p 89. Schickner, at Battelle, first learned how to deposit aluminum adherently on steel and described the procedure in an article published in *Steel* in 1953. The North American article repeats the procedure, but does not give appropriate reference to the inventor. It should probably also have been mentioned that the bath is the subject of U.S. Patent 2,651,608, issued to Brenner and Couch.

W. H. SAFRANEK
Battelle Memorial Institute
Columbus, Ohio

. . . and defended

To the Editor:

The North American Aviation process, while based to some degree on the Bureau of Standards work, is itself novel. Several patent applications relating to our process are pending at the present time. In all formal technical reports which have been written on our work, the Bureau of Standards has been given credit. Further, the North American Aviation process and results were not based on the waveguide and steel depositing work at Battelle and we feel that our process and the results actually represent a distinct improvement.

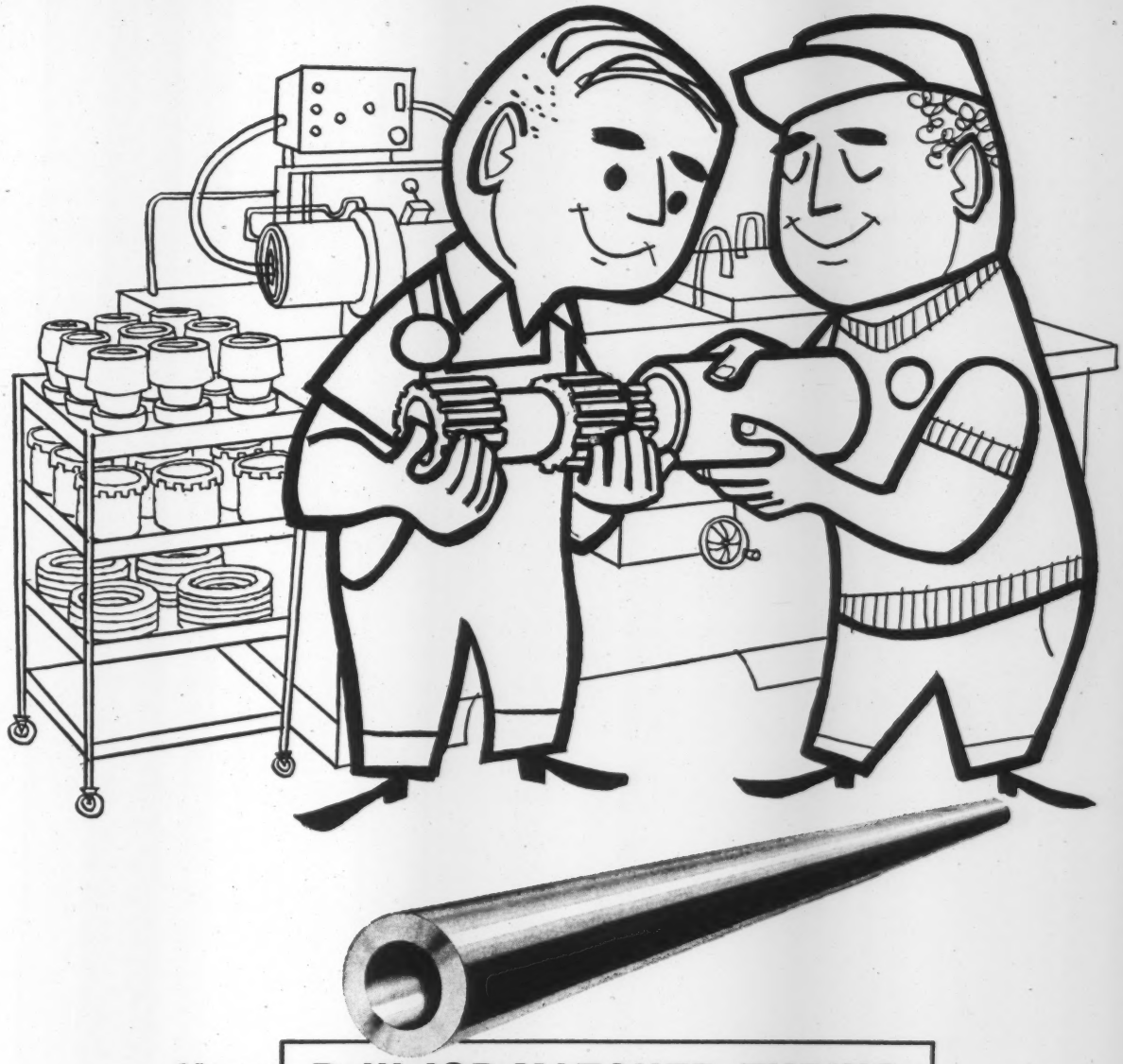
J. M. SYVERSON
Missile Div.
North American Aviation, Inc.
Downey, Calif.

The tough years

To the Editor:

"The Last Word" editorial, Mar '59, contained personal success and failure curves which were of interest. However, they are not conclusive. Several variables have been omitted.

For instance, in dental and medical professions, particularly in the former, an office is opened, and there the D.D.S. sits for weeks before his first patient shows up. It is considered unethical for dentists and doctors to solicit patients, i.e. work, as



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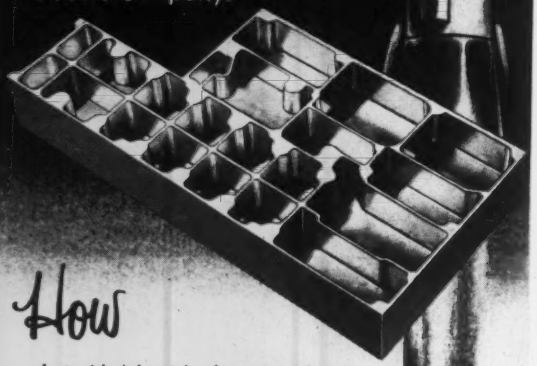
Who but Atlantic Casting?

This cast aluminum chassis protects vital electronic circuitry made for ATLAS by the General Electric Company.



How

but with Atlantic's plaster mold casting could these requirements be met?

- ▸ **SIZE:** 13″ x 6½″ x 2″ (overall) with .10″ walls.
- ▸ **SURFACE:** 125 microinches max. (as cast)
- ▸ **TOLERANCES:** ± .005 or less (as cast)
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- ▸ **FLATNESS:** .010 (overall)
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is common in other fields.

But whether the first five years are, or are not, the toughest, largely depend on business conditions at the time a student leaves school. A student entering the business world in depression years has a difficult time in securing a job of any kind. Some have walked the streets for months without success, and finally jumped at an offer of five dollars a week. This is much to their parents' disgust, for they have spent several thousand dollars on a college education for their son.

Those leaving college in boom years may find it tolerably easy to secure employment. There are deterrents, of course, such as the inability of an excellent student to sell himself, or a company official having a personal friend, etc. However, assume a position is secured. Everything may be satisfactory for a year or so, then business may start on a downgrade. The company cuts the staff, and the employee is out looking for another job in a business depression, all inside of five years. And his market is smaller.

So it is suggested that Mr. Clauser (who is to be complimented on his original idea) plot additional curves on occupations and business conditions to get a true picture of an engineer's life when "The First Five Years Are the Toughest."

CHARLES H. HUGHES
Staten Island, N. Y.

Porcelain enamel

To the Editor:

We refer to your interesting article about porcelain enamel, Aug '59, p 10. We are interested in knowing more about the dielectric properties of this finish. Would you recommend it to insulate steel panels placed in the arc zone of a circuit breaker of 600 v?

CLAUDE ROUSSEAU
President
Electrical Mfg. Co. Ltd.
Montmagny, Que., Canada

We suggest contacting Porcelain Enamel Inst., 1145 19th St., NW, Washington, D. C. for complete information on specific problems.

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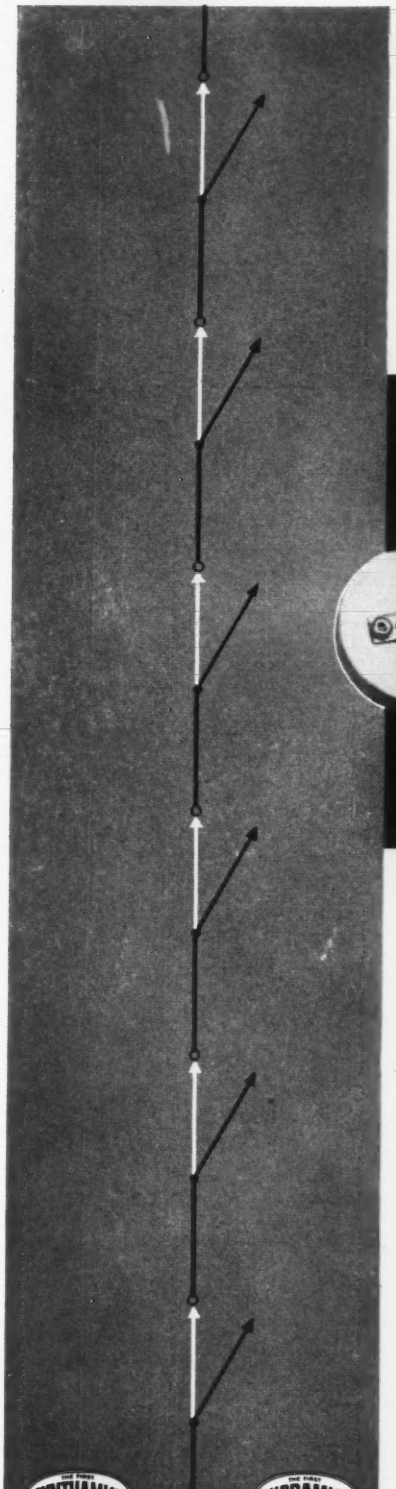

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PRICES AND SUPPLY

...AT A GLANCE

Increased production and use of practically all engineering materials has been predicted for 1960 by George R. Vila, executive vice president, U. S. Rubber Co. Here's what to expect: rubber—a record consumption of 1.6 million long tons, with synthetic rubber accounting for about 66% of the total; plastics—a record production of 6 billion pounds, up from an estimated 5.4 billion in 1959; steel—a record production of 127 million tons, up 10 million pounds from the previous record set in 1955.

Use of nonferrous metals will increase in 1960, though few records are expected to be set. According to Mr. Vila, the picture will look like this: aluminum—a record consumption of 2.3 million tons; copper—a 2% increase in consumption from an estimated 1.38 million tons in 1959 to 1.4 million tons; lead—a total consumption of 1.1 million tons, up from an estimated 1.0 in 1959; and zinc—an 8% increase in consumption to 1 million tons.

Consumption of synthetic fibers will more than double in the next ten years, according to Du Pont. Use of nylon, Orlon and Dacron, for example, will increase from 470 million pounds in 1958 to over 1 billion pounds by the early 60's. At that time, Du Pont's capacity to produce these fibers "will approach 600 million pounds per year."

Commercial production of foamed aluminum will begin within the next few months when Dynamic Metals Corp. finishes its 6-million-pound-per-year plant. Initial price of the foam, made by mixing zirconium hydride with molten aluminum and then extruding or molding, will be 75¢ to $1.00 per lb. Ultimately, Dynamic plans to build five other plants and to increase capacity to 29 million pounds per year.

Price of Viton synthetic rubber has been reduced $5 per lb by Du Pont. The material, introduced early in 1958 at $15 per lb, is used in aircraft, missiles and industrial applications at temperatures up to 600 F.

Greater availability of glass fiber will result from Pittsburgh Plate Glass Co.'s decision to add 8 furnaces to the 16 it originally planned to install in its new plant in Shelby, N. C. The 24 furnaces will have a total production capacity of 40 million tons per year.

Distilled scandium metal is now available in "experimental quantities" from St. Eloi Corp.

Plastics production will reach 11 billion pounds per year by 1970, according to Paul Mayfield, vice president and director, Hercules Powder Co. Mr. Mayfield attributes this doubling in production to increased use of plastics for new applications, particularly the replacement of bronze, aluminum and glass for certain uses. Mr. Mayfield also predicts that the automobile industry, which consumed about 100 million pounds of plastics in 1958, will use about 200 million pounds in 1965.

Nylon and polypropylene will soon be produced by Firestone Tire & Rubber Co. to satisfy its own needs for tire cord and industrial filaments. Nylon capacity will be about 12 million pounds per year. Polypropylene capacity and initial production date have not been revealed.

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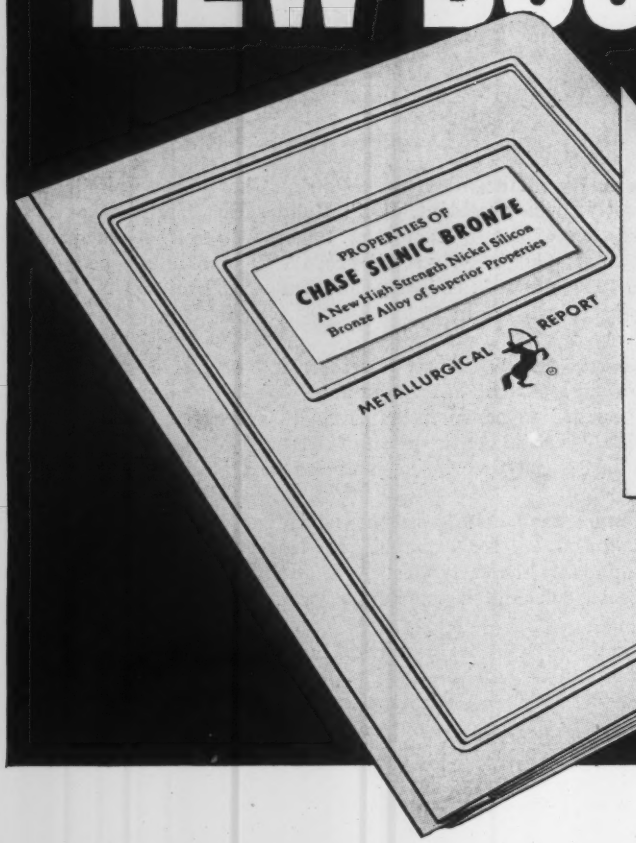
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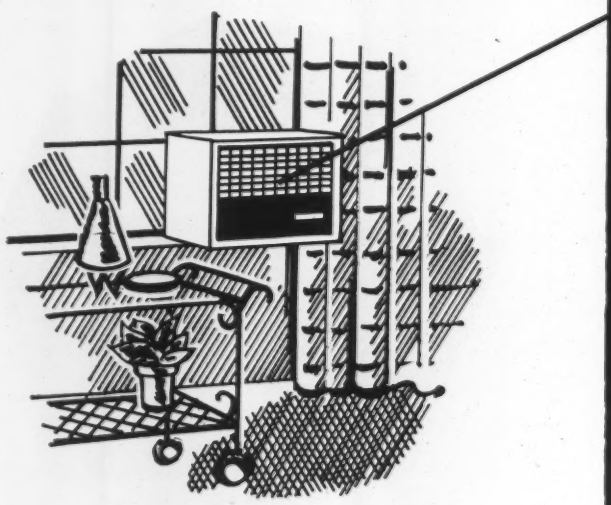

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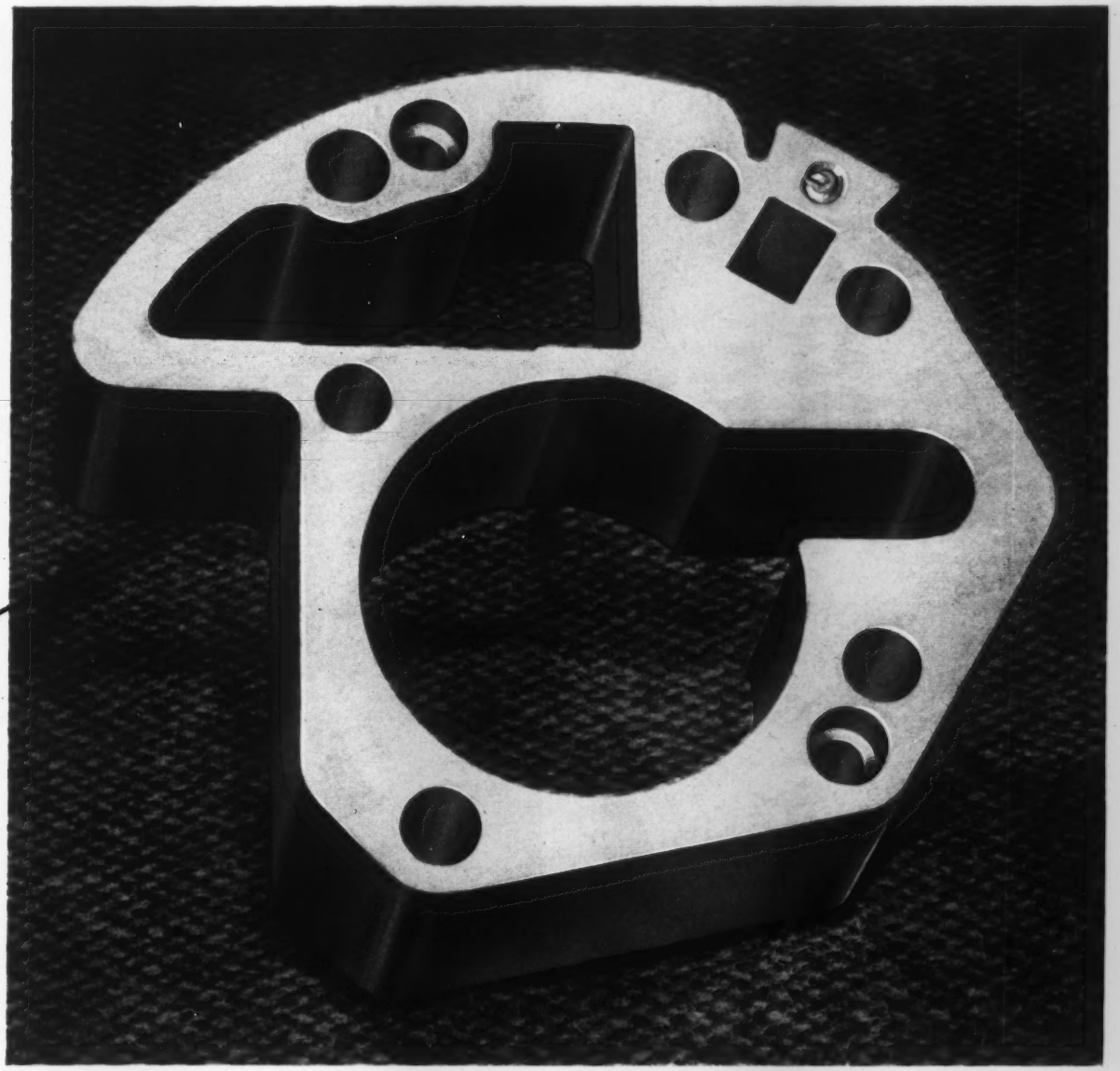

This part is shown 1½ times size. Actual weight: 2¼ lbs. X-271-2

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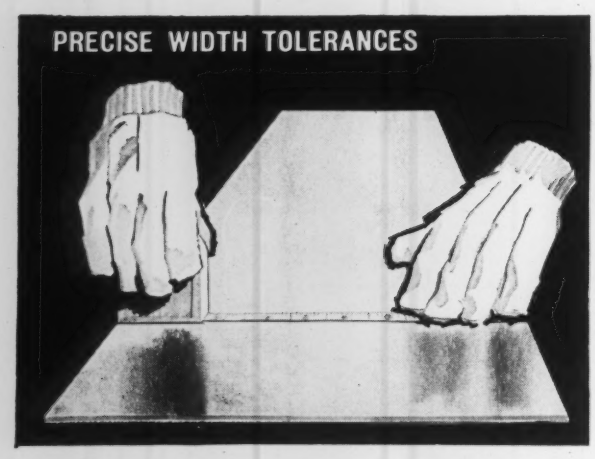
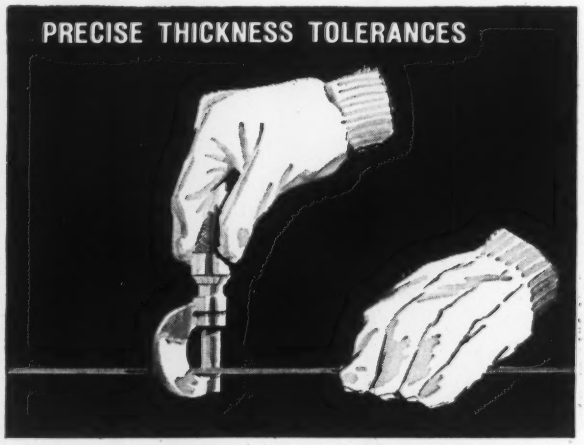
USS Amerstrip is a specialty product, rolled in quantities that permits production on precision machines, tailored to the customer's product specifications. When you use USS Amerstrip you get seven important "quality controls" not obtainable with other manufacturing methods.

The finish you get on your Amerstrip order has been specially prepared to meet *your* product's needs.



If your fabricating machines require a special width strip that's just what you'll get with Amerstrip. USS Amerstrip can be produced in any width under 24 inches . . . well within exacting tolerance limits.



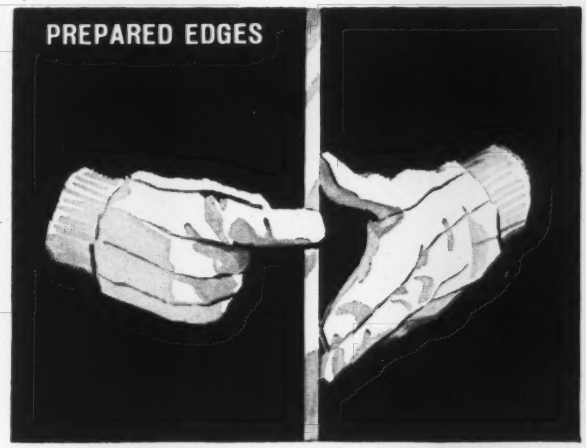
USS Amerstrip can be supplied in the thickness your machines demand. USS Amerstrip is fabricated on large production runs down to thickness tolerances as close as plus or minus .0005 inches.

American Steel & Wire representatives are experts in the fabrication and application of USS Amerstrip Cold Rolled Strip. Whenever you have a need or problem involving cold roll let these experts show you how USS Amerstrip can do it better. Get in touch with our nearest representative or write to American Steel & Wire, Dept. 9341, 614 Superior Ave., N.W., Cleveland 13, Ohio.

USS and Amerstrip are registered trademarks

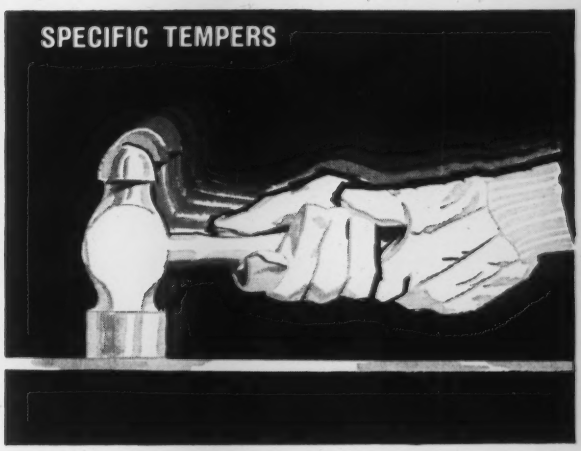
controlled" cold rolled strip steel

PREPARED EDGES



Because USS Amerstrip is produced in precision, order-size quantities, it can be supplied with the edge finish you need... square, standard, round, full round or bevel.

SPECIFIC TEMPERS



Whether your product must undergo a deep draw or other severe forming operation or require a special temper for rigidity, you'll get the exact temper you need when you order USS Amerstrip.

UNIFORM QUALITY THROUGHOUT

Whatever the size of your order . . . very large or very small, every coil of USS Amerstrip will be uniform in finish, in temper, in width and thickness. The use of USS Amerstrip will assure continuous production and high yields.

DESIGNED FOR END USE

This is really the sum total of all these other advantages. Because USS Amerstrip is "Quality-Controlled," because it is engineered to meet your needs, it assures you smoother, faster operation; a better, more salable finished product.

American Steel & Wire Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors
United States Steel Export Company, New York

For more information, turn to Reader Service card, circle No. 498

In 1946 J. Gordon Lippincott and Walter Margulies began what has proved to be one of the nation's most successful industrial design firms. Here their firm has chosen the new, exciting patterns of Sharonart* as the material for their advanced design room air conditioners.

Eliminating the conventional box-like unit Lippincott & Margulies have taken advantage of the principle of thermoelectric refrigeration and the beauty of Sharonart* to design units that are both attractive and functional. Fans, housed in the base or back of these units, force air over the cooling elements and circulate it throughout the room. Housings of perforated and painted or plated Sharonart* give the units added beauty while practically eliminating wear.

Tomorrow's room air conditioners designed by Lippincott and Margulies with

SHARONART

Patterned Steel

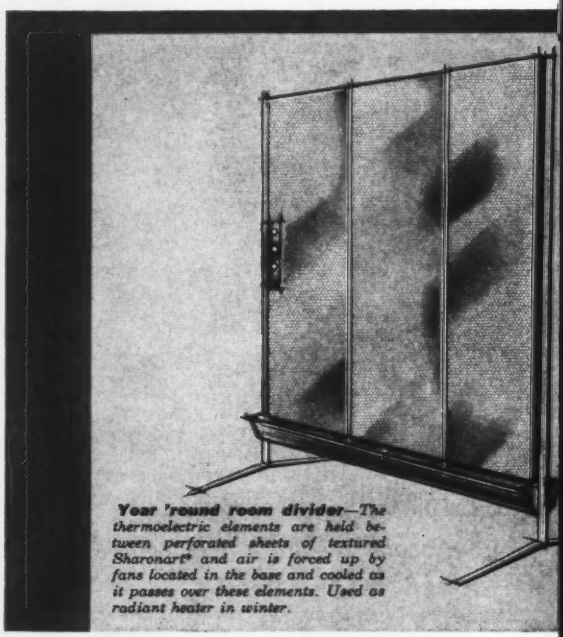
Sharonart* . . . the greatest advance in design steels in a decade . . . brings unequalled versatility to product engineers. Virtually any pattern can be rolled into one or both surfaces of stainless or carbon steels. It can then be fabricated as easily as plain steel . . . perforated, drawn, roll formed, stamped with few limitations. It can be painted, plated or coated by standard methods.

Here's new beauty, new style for your product without expensive retooling. Here's the ideal material for wear areas for most Sharonart* patterns hide scratches, fingermarks, etc.

Sharonart* is available in big production coils in a wide range of gauges and widths. Get the complete story, write for literature today.

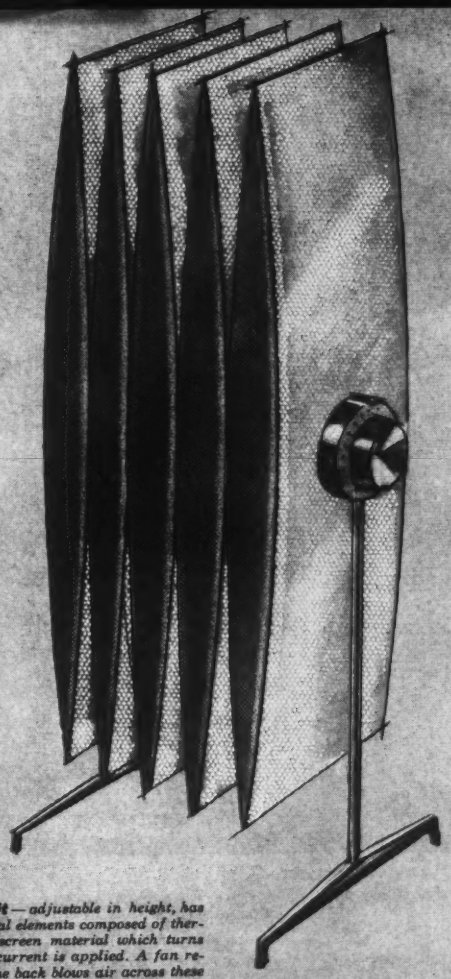
Sharon Steel Corporation, Sharon, Pa.

*TM



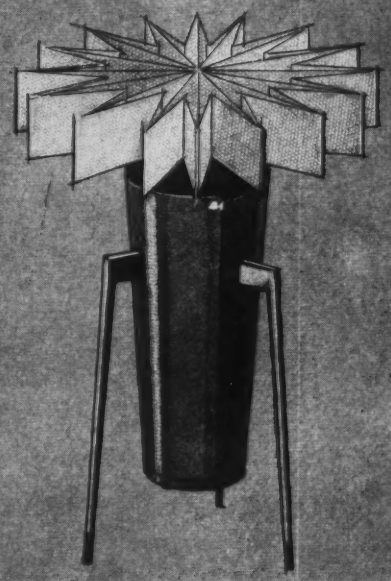
Year 'round room divider—*The thermoelectric elements are held between perforated sheets of textured Sharonart* and air is forced up by fans located in the base and cooled as it passes over these elements. Used as radiant heater in winter.*

SHARONSTEEL **SHARON** *Quality* **STEEL**

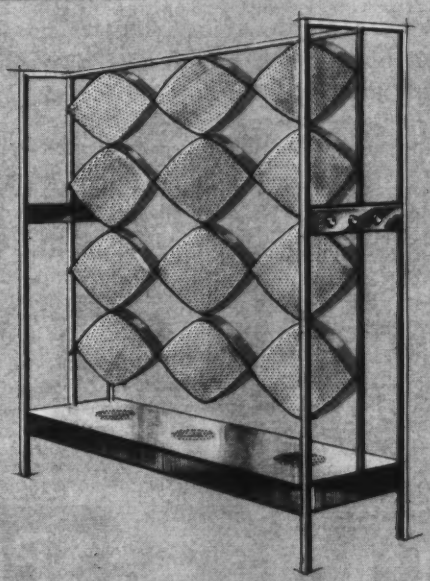


Floor unit— *adjustable in height, has five elliptical elements composed of thermoelectric screen material which turns cold when current is applied. A fan recessed in the back blows air across these elements and circulates it throughout the room. Housing of Sharonart® reduces wear, adds beauty.*

Portable unit— *Star shaped form on top is the refrigeration element and air is forced up by a centrifugal fan located in the base of the unit. Sharonart® is used in both tower and ring.*



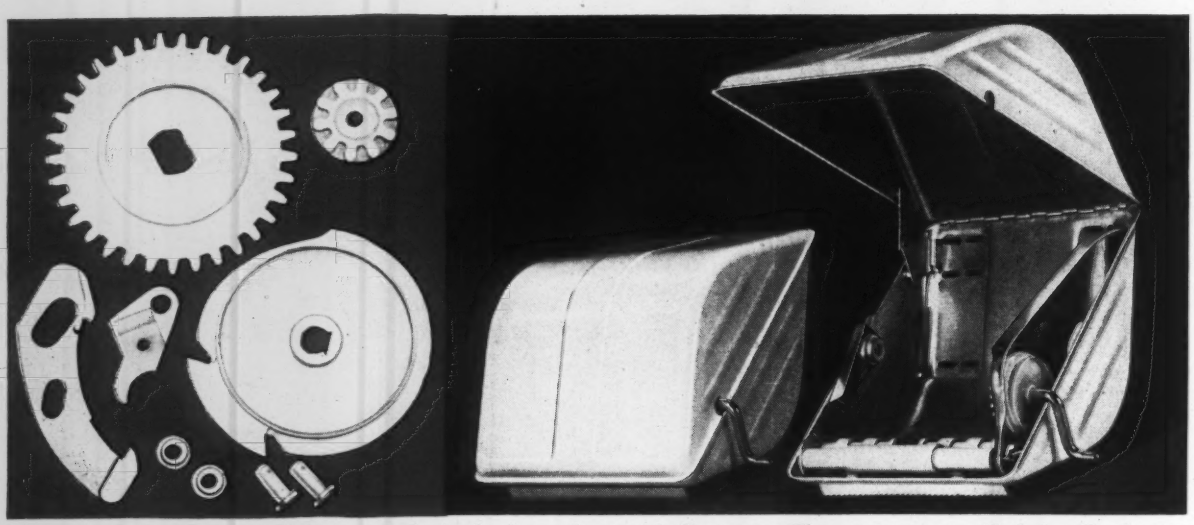
...unit—The upper half is made up of a thermoelectric ...t and air is blown up and through by a centrifugal ...unted in the base. A removable pan is provided to ...any moisture which may form on the sides. Fine and ...contrasting patterns of Sharonart®.



Decorative room divider— *Perforated Sharonart® provides unlimited design possibilities for large room units. Thermoelectric units are contained in perforated Sharonart® housings, fans in base of harmonizing Sharonart® pattern.*

For more information, turn to Reader Service card, circle No. 503

New ideas in **NYLON**



The use of nine Spencer Nylon parts instead of metal cut a pound from the weight of this Towlsaver paper towel dispenser. The parts are molded for Towlsaver by American Molding Co., San Leandro.

Spencer Nylon Gears Outwear Metal, Cut Product Weight, End Gear Noise

How Towlsaver, Inc., of Los Angeles produces a lighter, more quiet, trouble-free dispenser with parts molded from Spencer Nylon:

The moving parts in a paper towel dispenser must be able to take a lot of punishment. That's why Towlsaver, Inc., of 2639 South Garfield, Los Angeles, recently set out to find a better material to replace the metal gears in the Towlsaver dispenser. The metal gears, although case hardened, would eventually wear, and also were rather noisy.

The solution to this problem was found in tough, lightweight Spencer Nylon. The Towlsaver dispenser now contains nine parts molded from Spencer Nylon by the American Molding Co., 2002 Davis St., San Leandro, Calif.

"We are very pleased with the improvement in our dispenser since changing to nylon," reports Jack L. Perrin, president of Towlsaver, Inc. "By using nylon for these parts we have a virtually silent cabinet, and we have not experienced any gear failure because of wear. Also, the substitution of nylon has reduced the overall weight of our dispenser approximately one pound, which is an important freight saving."

There are important processing advantages, too, in Spencer Nylon. For one thing, Spencer Nylon contains far less water than other type nylons . . . saves you money because you don't have to dry it. Also, no other type nylon has the "body" needed for complicated shape extrusions.

It's easy to see why so many companies are switching to Spencer Nylon. For more information, contact Spencer's West Coast Sales Office, 1435 South LaCienega, Los Angeles.

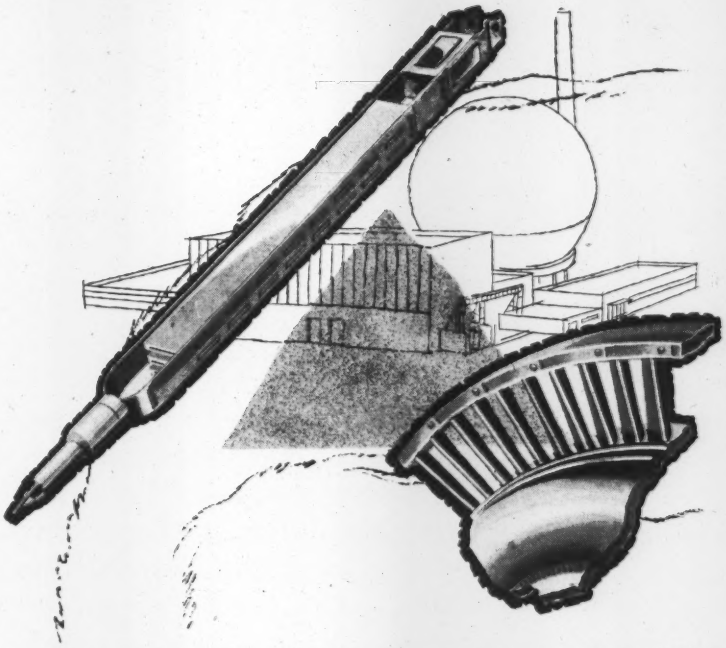
SPENCER®

SPENCER CHEMICAL COMPANY

SPENCER NYLON

General Offices. DWIGHT BUILDING, KANSAS CITY 5, MISSOURI

For more information, turn to Reader Service card, circle No. 462

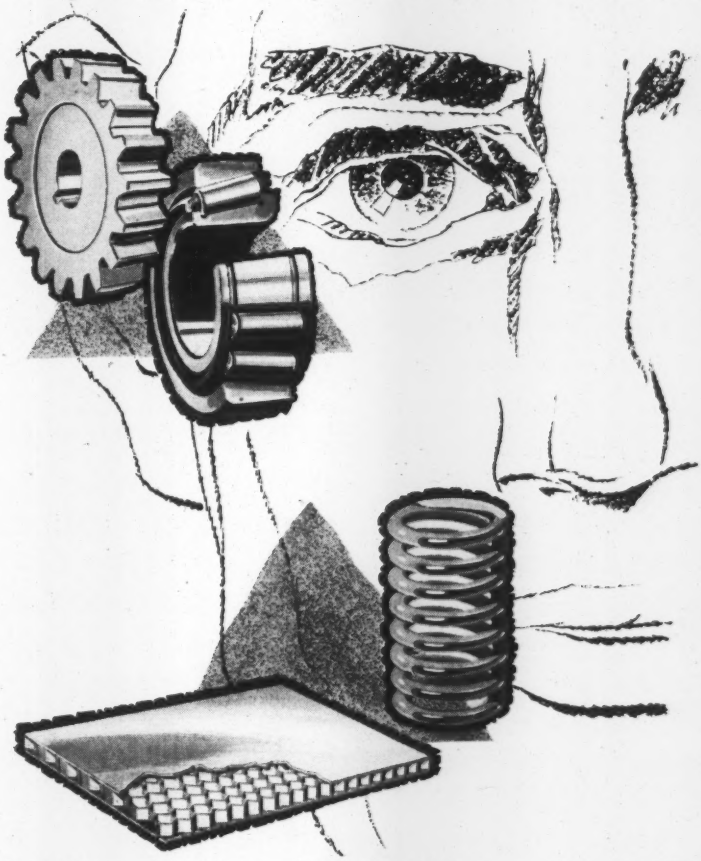


Today's metallurgical engineers and scientists are constantly meeting the challenge of sweeping technological advances. Electronic brains that solve "impossible" problems . . . jets and space craft which open brand-new horizons . . . reactors that produce fantastic amounts of nuclear energy. Advances such as these *demand* better metals . . . metals free of inclusions, with better electrical conductivity, increased hot strength, extended creep resistance and fatigue limits. In turn, better refractories are a "must" in order to precisely control purity and composition during the development of these metals.

Metal processors have long relied on the wide range of Norton Refractory products to precisely meet their re-

Dynamic Achievements With Purer Metals

..reflect the positive protection of Norton Refractories



quirements. High purity (99.5%) ALUNDUM* aluminum oxide, outstandingly stable to both oxidizing and reducing atmospheres . . . dense, fused, stabilized Zirconia for operations requiring an inert refractory for extremely high temperatures . . . nonwetting, nitride-bonded CRYSTOLON* silicon carbide...low boron MAGNORITE* magnesium oxide, ideal for vacuum melting. In addition, the Norton Man is constantly helping in process and product development. Backed by Norton Company's extensive engineering facilities, he can offer time and money-saving advice on all refractory problems.

Meet *your* processing requirements more efficiently and economically with Norton Products and Engineering. For complete details write NORTON COMPANY, Refractories Division, 350 New Bond Street, Worcester 6, Mass.

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

Making better products . . . to make your products better

NORTON PRODUCTS: Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electro-Chemicals — **BEHR-MANNING DIVISION:** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

For more information, turn to Reader Service card, circle No. 398

How NS solved another special steel problem

LENS GRINDING—the intermediate grinding stage, called "fining" is done on this type machine. The square piece of optical glass, with corners trimmed away, is mounted on an overhead chuck which bears down on the fining tool. The fining tool surface is covered with a round piece of wire cloth (man's finger is touching edge of wire cloth) which carries the emulsified emery abrasive used in grinding the lens.

WIRE CLOTH disk is laid over tool surface and pressed down. Pressure-sensitive backing holds wire cloth to tool surface during grinding operation.

NS-REYNOLDS WIRE CLOTH CUTS ERRORS FOR LENS MANUFACTURER

A leading manufacturer of ophthalmic and corrective eye glass lenses has eliminated tool wear, reduced lens grinding error and cut production time with a new integrated surfacing system for grinding tools, utilizing National-Standard Reynolds wire cloth as an abrasive carrier on the tool surface.

NS SOLVES A PROBLEM—Before the addition of the wire cloth tool facing, it was necessary to regrind the lens fining tools after every 3 or 4 lenses—a time consuming, costly procedure. The lens manufacturer came to the Reynolds Wire Division of National-Standard for help in finding a wire cloth with the high-degree of uniformity necessary to serve as a facing for the grinding tools. Reynolds Wire engineers recommended 0.007-inch, electrogalvanized steel wire woven to 30x30 mesh. Wire diameter was held to within a 0.00015-inch tolerance.

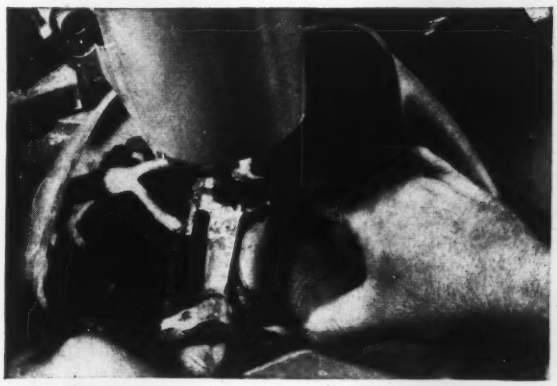
Under testing by the lens manufacturer, it was found that the wire cloth's uniformity allowed precision in grinding that virtually eliminated re-working. Grinding tools no longer needed retruing, human error in finishing was eliminated, and the wire cloth held the grinding abrasive uniformly across the tool face for greater accuracy.

EXPERIENCED ENGINEERING HELP of this kind, for jobs requiring specialty steel and wire is available to you from National-Standard. For the many thousands of applications where only specialty steel or wire will solve the problem, let National-Standard engineers go to work for you. Write for additional information to National-Standard Company, Niles, Michigan.

Manufacturer of Specialty Wire and Metal Products

NATIONAL NS STANDARD

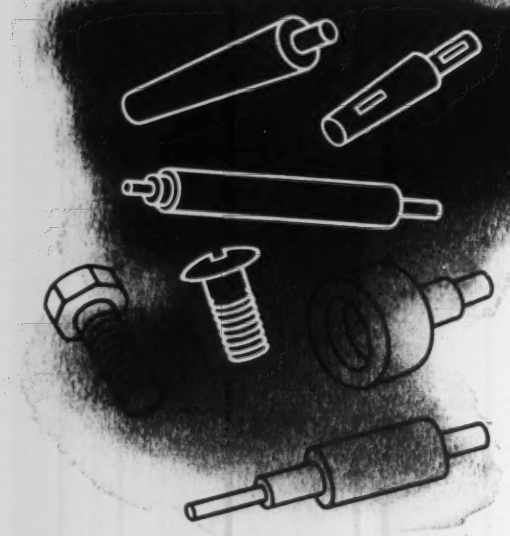
DIVISIONS: **NATIONAL-STANDARD**, Niles, Mich.; tire wire, stainless, music spring and plated wires • **WORCESTER WIRE WORKS** Worcester, Mass.; high and low carbon specialty wires • **WAGNER LITHO MACHINERY**, Secaucus, N. J.; metal decorating equipment • **ATHENIA STEEL**, Clifton, N. J.; flat, high-carbon spring steels • **REYNOLDS WIRE**, Dixon, Ill.; industrial wire cloth • **CROSS PERFORATED METALS**, Carbondale, Pa.; decorative, commercial, and industrial perforated metals.



GRINDING TOOL with wire cloth layer is inserted into bottom chuck of fining machine. Chuck rotates the tool for about 8 minutes during fining operation.

LENSES go through fining operation in one of four machines shown in the foreground before being polished in machines at the rear. The addition of wire cloth has also cut the fining operation time.

For more information, turn to Reader Service card, circle No. 476



Machine it! Put it to work!

Prehardened

VISCOUNT 44

High Strength Steel

No Further Heat Treatment Necessary!

Here's the high strength steel that cuts engineering and maintenance problems to the bone on maintenance and machine tool applications. Unexcelled strength, good toughness and increased wear resistance—these are the advantages of VISCOUNT 44, even when exposed to temperatures up to 1000°F.

More important, risk of size change and distortion of critically-engineered parts during heat treatment is completely eliminated. VISCOUNT 44 is furnished prehardened at Rockwell C 42-46 . . . it's practical to machine . . . easy to work!

NOMINAL ANALYSIS

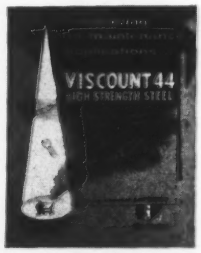
Carbon	.40	Chromium	5.00
Silicon	1.00	Molybdenum	1.20
Manganese	.75	Vanadium	1.00

plus Alloy Sulphides

MECHANICAL PROPERTIES

Furnished Hardness	RC 42-46
Tensile Strength	180,000-220,000 psi
Yield Strength (0.2% offset)	160,000-200,000 psi
Reduction of Area	40-50%
Elongation, 2"	10-15%
Coefficient of Expansion 80-1000°F	7.0 x 10^{-6} inches/inch°F

Have a high strength steel problem? Call a Latrobe sales engineer today! Or, send for VISCOUNT 44 literature.



TYPICAL APPLICATIONS

Spindles • Shafts • Brake Dies • Forming Rolls • Tie Rods
Arbors • Axles • Bolts • Structurals • Cams

LATROBE Metalmasters

LATROBE STEEL COMPANY
LATROBE, PENNSYLVANIA

BRANCH OFFICES and WAREHOUSES:
BOSTON • BUFFALO • CHICAGO • CLEVELAND • DAYTON
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For more information, turn to Reader Service card, circle No. 499

Thought about DS quality for STAINLESS STEEL CASTINGS?

Here's a time-and-money saving suggestion: When your design problem involves stainless steel castings, take a tip from engineers everywhere and keep DS *quality* high in your engineering thinking.

And for good reason.

The same quality that is manufactured in Dodge ductile iron, carbon, and low alloy castings is available to you in DS *stainless steel* castings, too.

For better customer service, we've added a host of new facilities to produce DS quality stainless steel castings. This is part of our "look ahead" expansion program that anticipates your needs for quality foundry and machine shop products.

Perhaps the castings shown on this page will serve to spark an idea of how Dodge can be of assistance for your stainless steel casting needs. We'd be happy to quote on your requirements. Good thought: Why not let us do it *today?*

DS

DODGE PRODUCTS

DODGE STEEL COMPANY

6501 State Road • **Philadelphia 35, Pa.** • DEvonshire 2-2200

Stainless

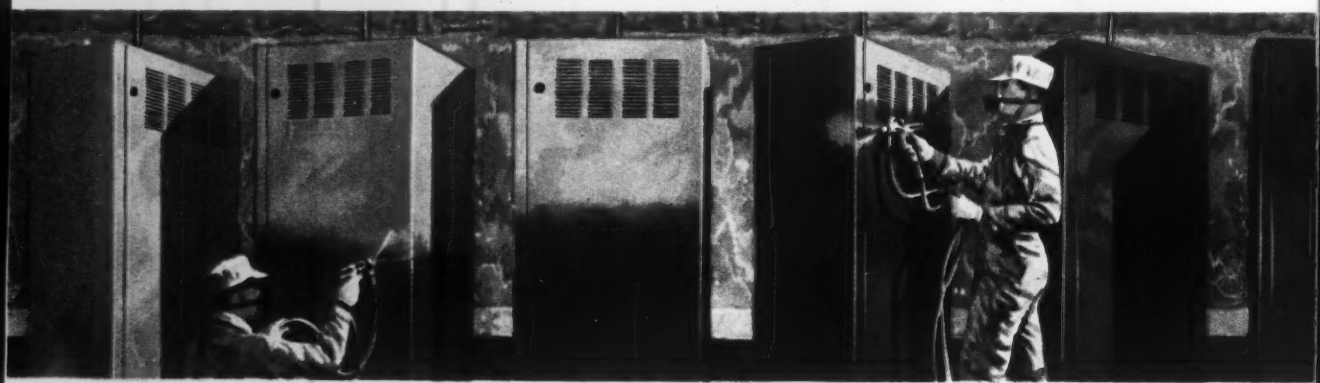
THE MOST IMPORTANT ALLOY IN A STEEL CASTING IS QUALITY

For more information, turn to Reader Service card, circle No. 433

A topcoat of Du Pont DULUX® Ename

MODERN CONCEPT IN VENDING is multiple units serving a wide variety of foodstuffs and coordinated in design and color. These new models wear a topcoat of durable, lustrous "Dulux" enamel in "Buckskin Beige" . . . a color recommended by Du Pont color specialists for maximum sales appeal. Du Pont also custom blends over 30 colors to individual customer specifications for Vendo.

DURABLE "DULUX" Enamel will keep t newest cooler for Coca-Cola* looki fresh and attractive. "Dulux" on tho sands of coolers in service resists chippi and cracking despite sun, weather a temperature extremes.



TWO-STAGE FINISHING of vending equipment for Coca-Cola* involves two spray operators, using the Du Pont steam-spray system. One man sprays the lower half of the equipment with "Dulux"; the other completes the job as the conveyorized parts move in front of him. Du Pont Pink Primer is used exclusively by Vendo for a first coat. The steam-spra system, which uses superheated steam instead of compressed air, puts more paint with one pass of the spray gun . . . cuts overspray and wast

*"COCA-COLA" IS A REGISTERED TRADEMARK OF THE COCA-COLA COMPA

Du Pont Finishes Service Package—FORMULATION, APPLICATION,

keeps VENDO equipment "dressed up" for sales

- Specially formulated finishes developed by DuPont have tested point-of-sale appeal
- Rugged "Dulux" retains its beauty under toughest service conditions
- Help on every phase of finishing is typical of the cooperation you can expect from Du Pont

Durable, eye-catching finishes are important to The Vendo Company of Kansas City, Missouri, world's largest manufacturer of automatic merchandising equipment. Their selection—rugged "Dulux" enamel, specially formulated and tested for sales appeal and durability by Du Pont research.

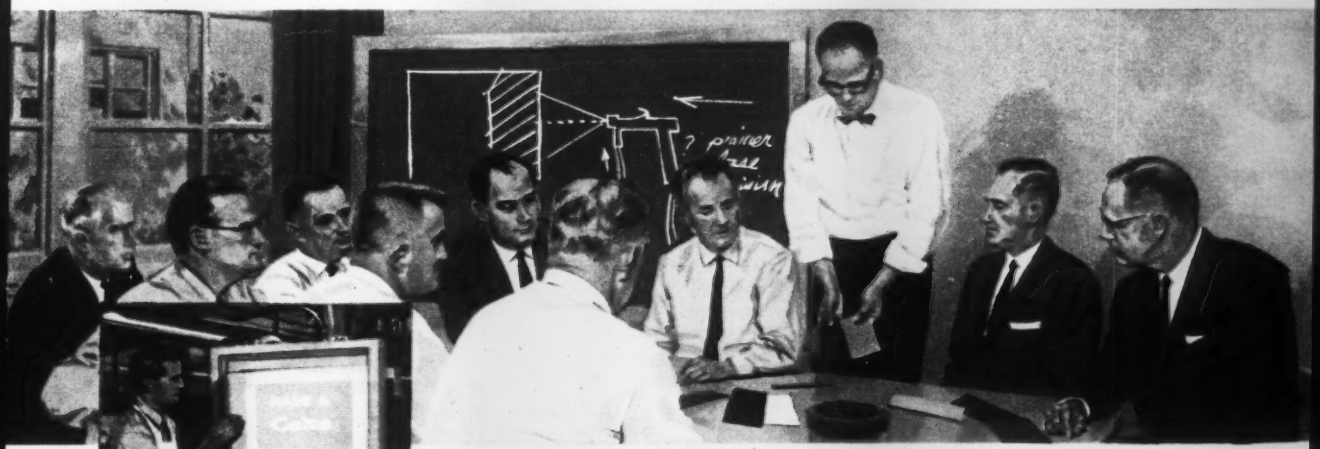
Du Pont's custom blending service also helps Vendo match the rigid color specifications of its many customers. And Du Pont service men make sure these finishes are properly applied. They frequently study production line operations...run checks on both equipment and finishing materials . . . give on-the-spot technical advice. Result: today Vendo uses "Dulux" *more* efficiently than ever before.

Like Vendo, most manufacturers can benefit when experienced Du Pont personnel work with them to assure efficient use of industrial finishes. Here is experience *in depth* . . . not only from technically trained Du Pont salesmen and service men, but also from the field service laboratories of the world's foremost paint-research organization.

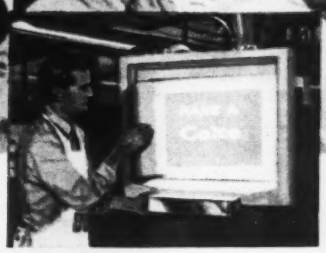
Du Pont specialists have the background and "know-how" needed to apply finishes by any method, in practically any industry. They'll recommend a finishing system that can solve your particular problem . . . work with your personnel on a continuing basis. Best of all, *they can help you develop better finishing at lower costs!*

If finishing is a key part of your production, it will pay you to see a Du Pont representative. Write: E. I. du Pont de Nemours & Co. (Inc.), 2502 Nemours Bldg., Wilmington 98, Delaware.

VISCOSITY TEST is made in the paint circulating room where "Dulux" enamel and thinners are blended in 16 special 60-gal. mixing tanks. Du Pont service men frequently check these mixtures before they are piped down to the spray line.



KEY VENDO PERSONNEL meet regularly with Du Pont representatives to review ways and means of improving efficiency, cutting costs. Here George Osborn of Du Pont finishes research discusses new techniques and product developments with (right to left) S. L. Childers, vice president in charge of operations; L. G. Orr, purchasing department; M. J. Asch, finishing supt.; G. H. Hansen, Jr., director of engineering; J. H. Pearce, plant supt.; O. J. Spawn, Du Pont regional technical supervisor; C. T. Stiers, paint-process engineer; P. L. Mitchell, Du Pont technical representative; C. J. McKeown, Du Pont salesman.



SILK SCREENING with gleaming "Dulux" white enamel puts the finishing touch on these smartly designed vending machines for Coca-Cola*. This high-hiding white covers the red in just one coat . . . *stays* white over an extra-long service life.

*"COCA-COLA" IS A REGISTERED TRADEMARK OF THE COCA-COLA COMPANY.

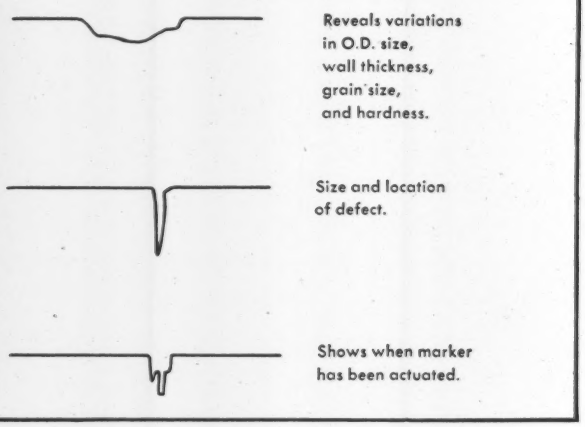
FOLLOW-THROUGH—*Sets Today's Production Pace*

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

For more information, turn to Reader Service card, circle No. 547

NEW DAMASCOPE TEST


Reveals variations in O.D. size, wall thickness, grain size, and hardness.
Size and location of defect.
Shows when marker has been actuated.

This flaw is .004 square inches in area
Damascope revealed exact size and location

Here is a new and improved method of eddy current inspection that guarantees each and every piece of Damascus pressure tubing will meet your specifications. Damascope reveals not only the presence of flaws, but their exact size and location. Tubes with surface or sub-surface cracks, seams, splits, holes and inclusions are automatically indicated and rejected.

Over one million inspection feet were run to prove the new test which Damascus now employs as a regular production check on pressure tubing quality.

DAMASCOPE "Eddy Current" Test Meets ASTM Area Size Limits on Flaws

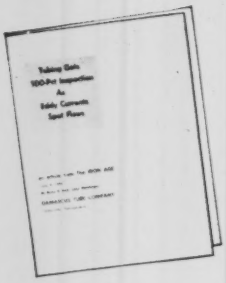
Gauge	Wall Thickness (in.)	Minor Dimension of Defect (Length or Depth) (in.)	Area Size Length x Depth (sq. in.)
20	0.035	0.005	0.0020
18	0.049	0.006	0.0024
17	0.058	0.007	0.0028
16	0.065	0.008	0.0032
15	0.072	0.009	0.0036
14	0.083	0.010	0.0040

Tubing passed by Damascope is guaranteed to meet A.S.T.M. specifications as outlined in the Book of Standards, Part 1, covering ferrous metals.

If you employ more stringent requirements, Damascope can be set to even finer sensitivity to yield a super tube at only a slight premium.

SUITABLE FOR NUCLEAR WORK

For nuclear or other critical applications, Damascope can be even more closely calibrated to yield a tube of super quality. Damascope is powered by batteries which eliminate the variable effects caused by current surges. It also employs modulation analysis to separate eddy current signals from background interference.



FOR COMPLETE INFORMATION ON DAMASCOPE TESTING

Write today for four-page bulletin explaining operation and other pertinent data on Damascope inspection.

FORMED STEEL TUBE INSTITUTE

AMERICAN STEEL WAREHOUSE ASS'N

DAMASCUS TUBE COMPANY

STAINLESS STEEL TUBING AND PIPE

GREENVILLE, PENNSYLVANIA

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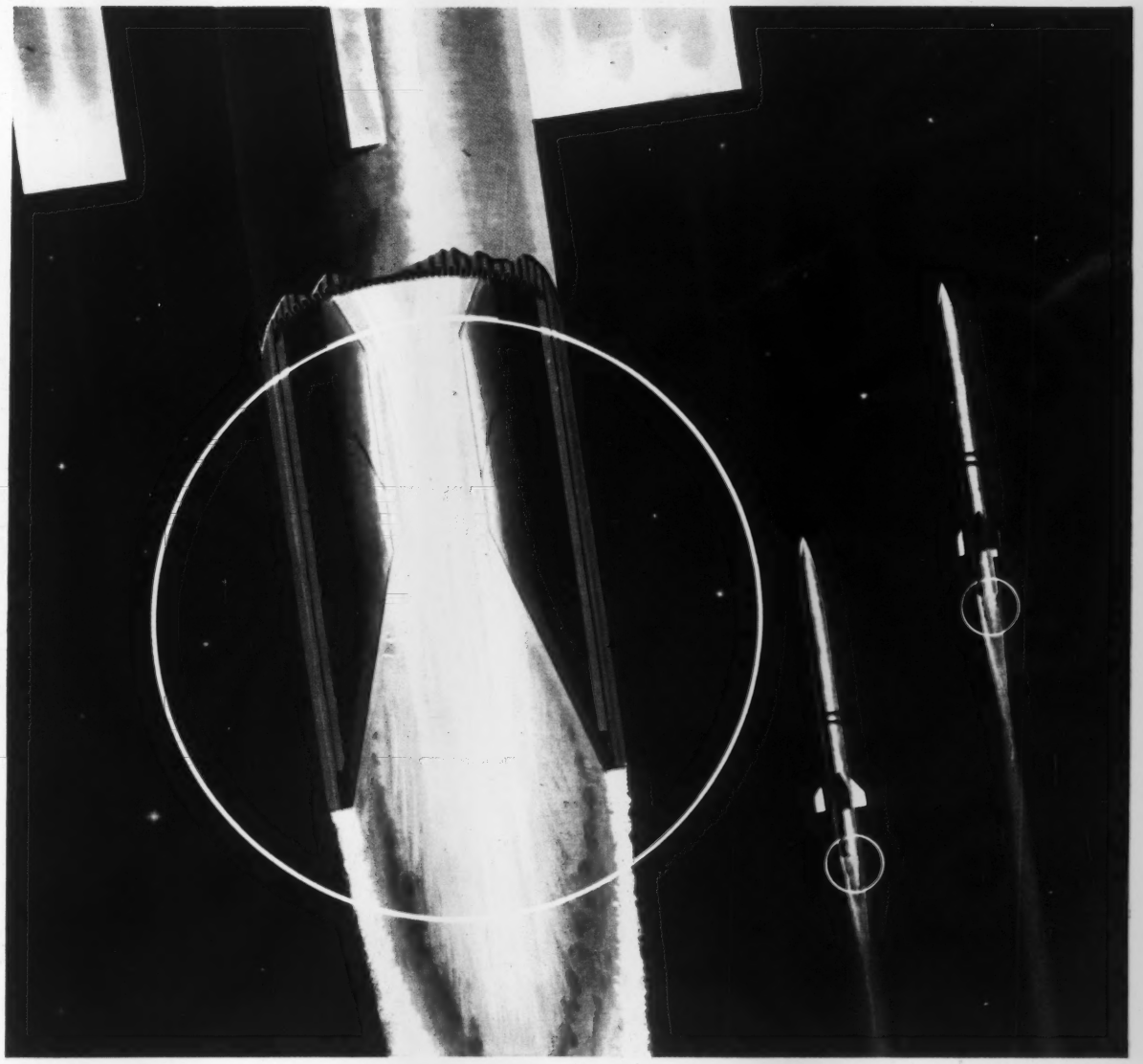

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Aluminum Extrusions, Castings, Forgings. Aluminum Co. of America, 20 pp, illus. Applications, properties and design data for aluminum extrusions, screw machine products, castings and forgings. 2

ABS Rigid Plastics Pipe. American Hard Rubber Co., Div. of Amerace Corp., 16 pp. illus., No. CE-80. Corrosion resistance, fabrication data, dimensions and uses of ABS (acrylonitrile-butadiene-styrene) rigid plastics pipe, fittings and valves. 3

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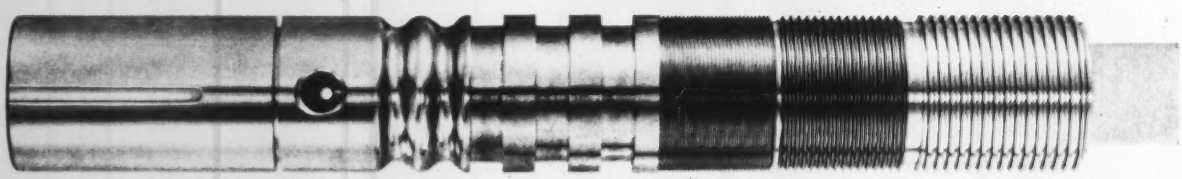

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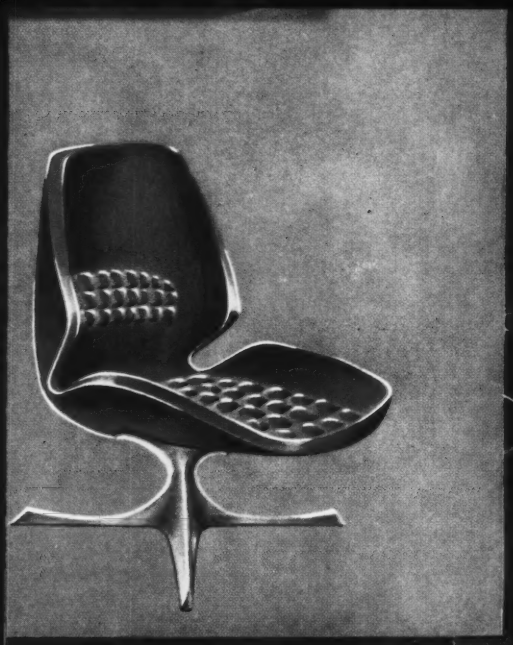
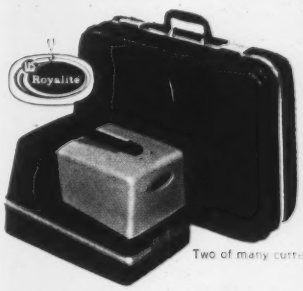


Shape your product future with U.S. Royalite®

ABS THERMOPLASTIC SHEETS

Here is a versatile thermoplastic sheet material that forms to *any* shape in sharp detail—and still answers the basic design problems of toughness, beauty and economy. Used as a tool for advanced thinking, U.S. Royalite makes new, modern product designs practical. Check these advantages: (1) Royalite is extra tough to resist hard knocks and scrapes, is impervious to grease and oil, nonrusting and unaffected by most chemicals. (2) Royalite molds cleanly, without seams or sharp edges to snag or chip. (3) Royalite gives you new textured beauty in a wide range of colors built in to last. (4) Royalite is extra light, making portable products even more portable. (5) Royalite is economical to use. Advanced fabricating techniques permit its wide use on popular-priced items. Send for free, file-size specifications booklet.



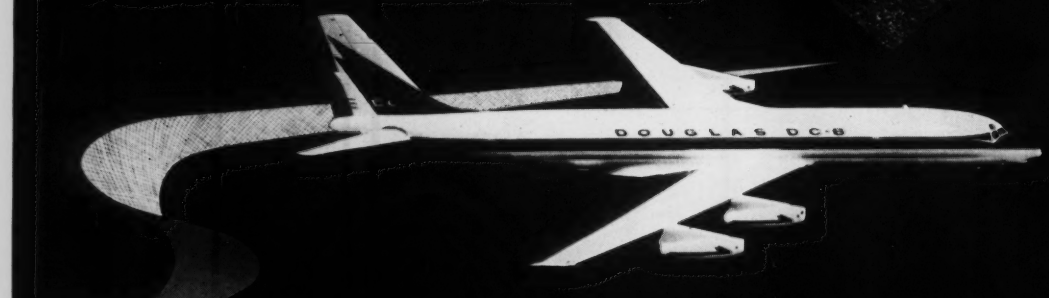
Two of many current applications of U.S. Royalite

ROYALITE PLASTIC PRODUCTS

United States Rubber

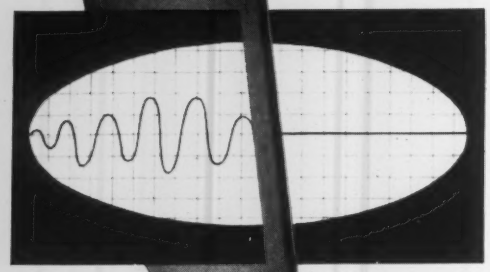
2638 North Fulton Rd., Chicago 39, Illinois

New Fabric Uses *POWDERED LEAD*



To Hush Jetliner's Roar

Ounce-conscious aircraft designers find LEAD worth its weight in unique sound attenuation properties



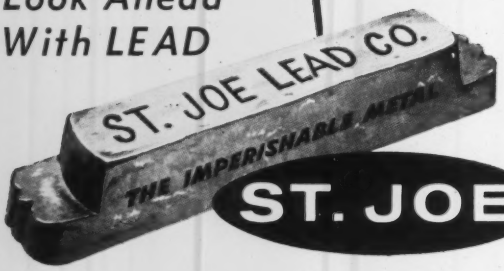
Sound attenuation is the ability or property of absorbing or deadening sound—and lead was the only material that could do the job effectively and inexpensively in this new airborne acoustical fabric.

Called Coustifab*, the new material is made of either cotton or glass fabric coated with Goodrich Geon polyvinyl material compounded with *powdered lead*. It is being used in the ceilings and rear side panels of the new Douglas aircraft to absorb low frequency vibrations which normal acoustical material cannot handle.

This exceptionally flexible way of using lead opens new avenues of application for this versatile metal. By varying the lead content which may run as high as 80% by weight depending upon the specific use, the new fabric may have a wide potential for office machines, X-ray rooms, building materials, industrial plants and other places where the unique silencing or protective properties of lead are required.

*Product of Cordo Chemical Corporation, Norwalk, Conn.

Look Ahead With LEAD



ST. JOE

ST. JOSEPH LEAD COMPANY

250 PARK AVENUE NEW YORK 17, NEW YORK

The Largest Producer Of Lead In The United States

PB-145

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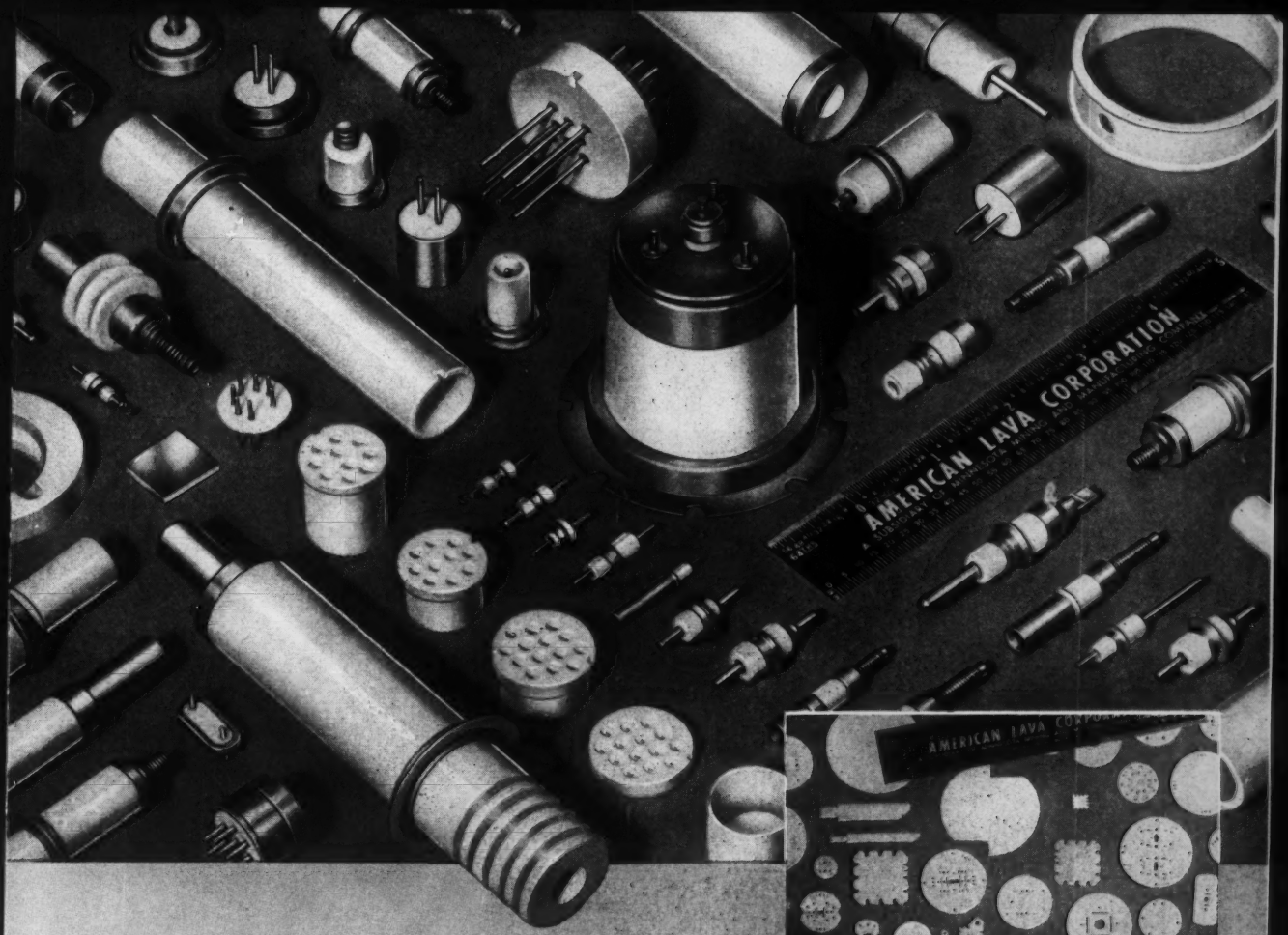
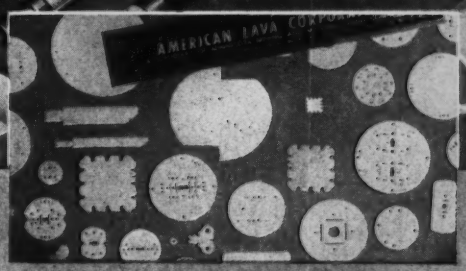




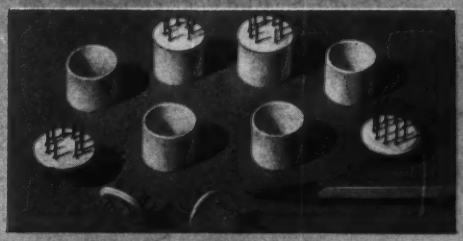
AlSiMag pioneered micro-miniature ceramics . . . some as thin as 0.005". Relatively high strength, superior performance at high temperatures, high frequencies. Excellent record for withstanding fatigue, heat, shock, vibration.

RELIABILITY

IS AN OUTSTANDING CHARACTERISTIC OF AlSiMag® CERAMICS

AlSiMag Ceramics offer exceptional resistance to heat and erosion. They have marked electrical and physical stability at elevated temperatures and in varying environments. Chemically inert. Good strength. Can be accurately fabricated in micro-miniatures.

AlSiMag Ceramics include many special purpose ceramics, some especially adapted to hermetic sealing. Widest choice of materials, more than half a century of specialized experience. Send blue print and operating conditions.



The AlSiMag Ceramics in these multiple pin headers may be safely used up to 2800°F. The metal components are the limiting factors.

These tantalum pins with nickel braze alloy operate around 1000° F. All materials are rugged. Strong hermetic seal. Low vapor pressure. High temperature bake-out is practical.

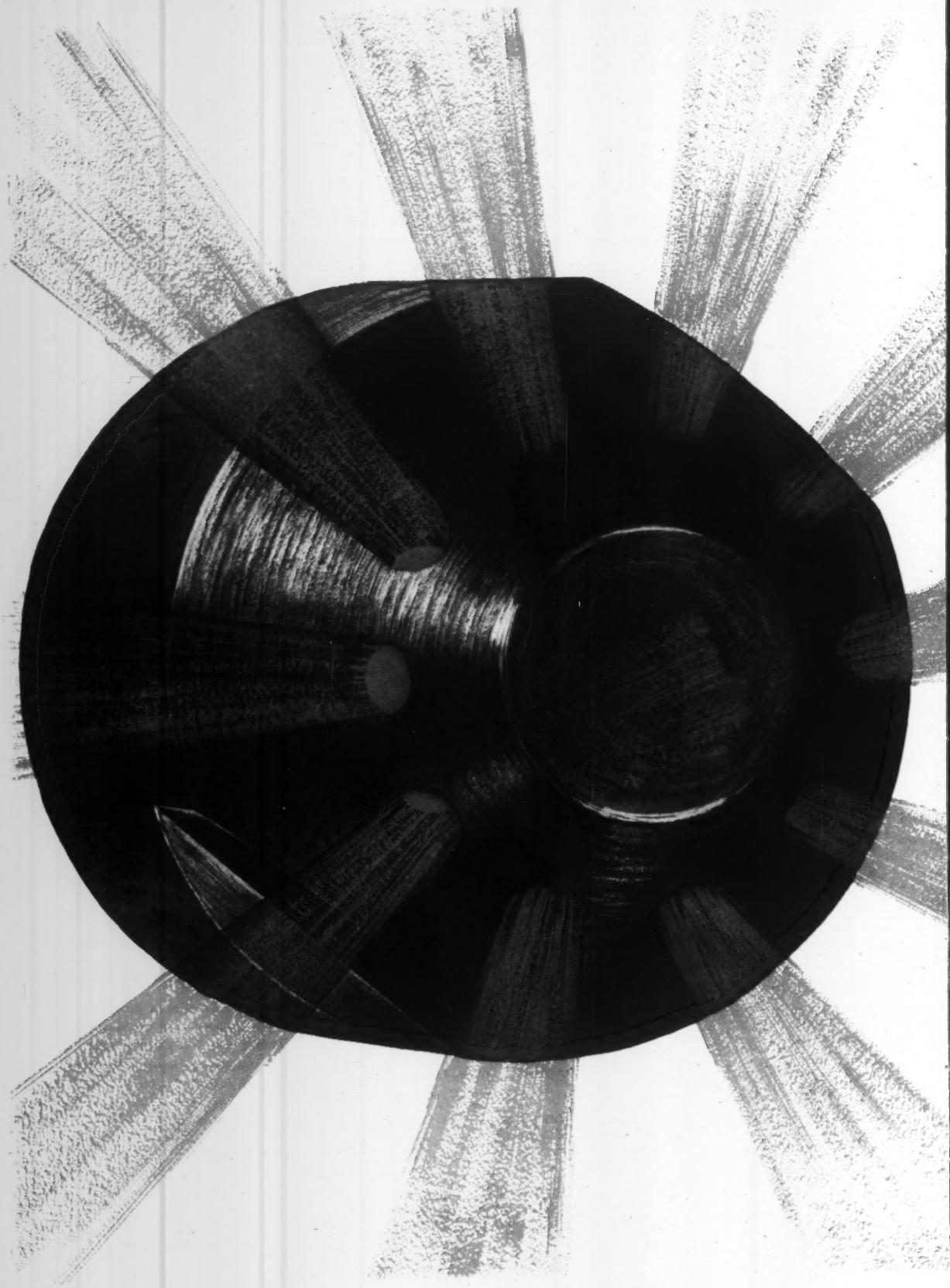
A Subsidiary of Minnesota Mining and Manufacturing Company

AMERICAN LAVA CORPORATION

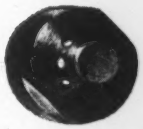
CHATTANOOGA 5, TENN.
58TH YEAR OF CERAMIC LEADERSHIP

For service, contact American Lava representatives in Offices of Minnesota Mining & Manufacturing Co. in these cities (see your local telephone directory): Boston: Newton Center, Mass. • Chicago: Bedford Park, Ill. • Cleveland, O. • Dallas, Texas • Los Angeles, Cal. New York: Ridgefield, N. J. • Philadelphia, Pa. • St. Louis, Mo. • St. Paul, Minn. • So. San Francisco, Cal. • Seattle, Wash. All other export: Minnesota Mining & Manufacturing Co., International Division, 99 Park Ave., New York, N. Y.

For more information, turn to Reader Service card, circle No. 450



FOR THE MACHINERY PART THAT TAKES THE BEATING



Critically contoured holes in burner nozzles made of high alloy steel . . . distorted in two days. Mild steel corroded in two hours. But HASTELLOY alloy B nozzles now last several months . . . despite the punishing, high-velocity flow of steam-atomized fuel oils containing sulphuric acid, sulphur compounds, and other corrosive agents.

It's just one more example of why thousands of design and production engineers looking for tough metals for machinery parts . . . specify HAYNES alloys.

If design and production in your field demand really tough metal parts, look into HAYNES alloys. There are more than 15 to choose from, including HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. All parts can be furnished machined or ground to specified size and finish.

HAYNES Alloys *will do the job!*

HAYNES ALLOYS

HAYNES STELLITE COMPANY

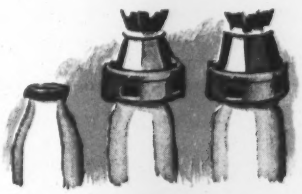
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

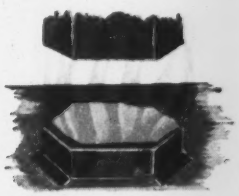
Address inquiries to Haynes Stellite Company, 420 Lexington Avenue, New York 17, N. Y.

The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

TYPICAL MACHINE PARTS OF ABRASION-RESISTANT "HAYNES" ALLOYS



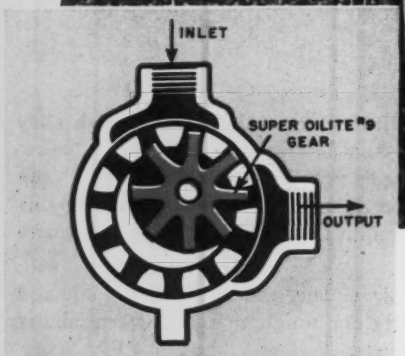
MILK BOTTLE CAPPER sealing-segment fingers, investment cast of HAYNES STELLITE alloy No. 6, capped 100-million bottles in five years without noticeable wear.

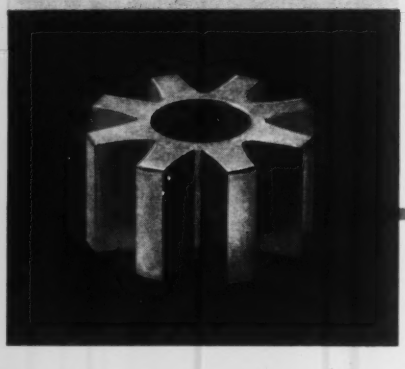


DIE LINERS cast from HAYNES 93 alloy have worn only 0.015 in. while making 20,000 bricks from highly abrasive materials, far outlasting other metals.

HALF BUSHINGS made of HAYNES STELLITE alloy No. 6B are used as can headers of a machine that makes 300 milk cans a minute.

For more information, turn to Reader Service card, circle No. 492





Double Sprayer Output, Cut Costs 75% with Oilite Precision Gear

The search for a more durable star gear at less cost led Hahn, Inc., Evansville, Indiana to investigate Amplex powder metallurgy. Amplex engineers came up with an answer that far exceeded Hahn's expectations.

Formerly machined from cast bronze, the gear is now produced in a single press operation of hardened Super Oilite No. 9†. By eliminating scrap and machining operations like turning, boring, cut-off and hobbing, Amplex reduced the cost of the gear approximately 75%. But that's not all . . .

Despite exposure to acid-forming, gritty fertilizers and pesticides, the oxide-coated Oilite gear proved 5 times more durable than its predecessor! Tough Super Oilite No. 9 proved so remarkably wear-resistant, Hahn was able to double the pump's gpm output.

What do *you* look for in components—lightweight, close tolerances, corrosion resistance, wear resistance or superior surface finish? Amplex can supply quality-controlled parts in volume that meet *all* of these requirements.

To put superior performance at less cost into your products, contact the nearest Oilite Engineer. Look for him in the Yellow Pages under "Bearings" or write Department T-11.

† Only Chrysler makes Oilite

QDP or PDQ?*

Why risk excessive production and warranty costs? You can depend on Amplex for top *quality* components, prompt *delivery* and a reasonable *price* . . . QDP! The result is parts that reduce your manufacturing and selling costs.

* Quality-Delivery-Price vs. Price-Delivery-Quality

SINCE 1929 — A CHRYSLER OILITE PRODUCT

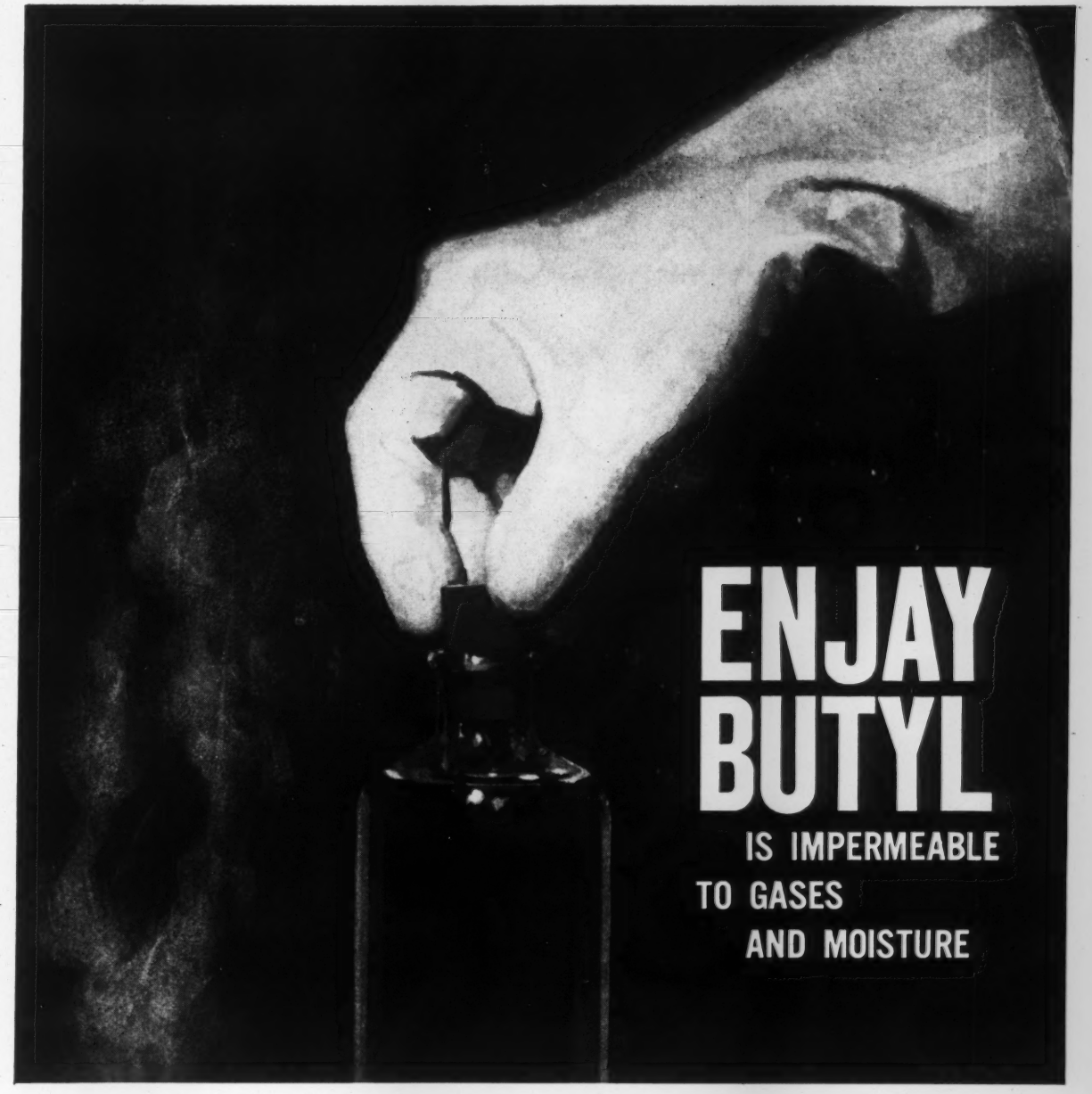
the most trusted name in powder metallurgy!

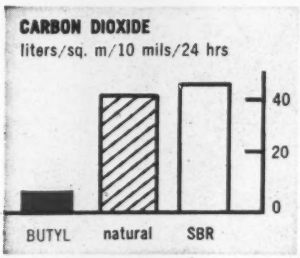
AMPLEX DIVISION

CHRYSLER CORPORATION, DETROIT 31, MICHIGAN

PRECISION PARTS • SELF-LUBRICATING BEARINGS • METAL FILTERS • FRICTION UNITS

For more information, turn to Reader Service card, circle No. 386





The impermeability of Butyl to carbon dioxide is demonstrated when compared with natural rubber and SBR.

Enjay Butyl rubber offers unmatched impermeability to gases, moisture and moisture vapor. Many applications prove Butyl retains air pressure 8 times better than natural rubber. Butyl outperforms natural and synthetic rubber in such applications as inner tubes, jar and bottle seals, inflatable sporting goods, window seals, hoses...wherever an impermeable barrier is required.

Butyl also offers outstanding resistance to sunlight and weathering . . . chemicals . . . heat . . . abrasion, tear and flexing . . . superior damping and unmatched electrical properties.

Find out how versatile, low-cost Butyl can improve your product. Call or write your nearest Enjay office.

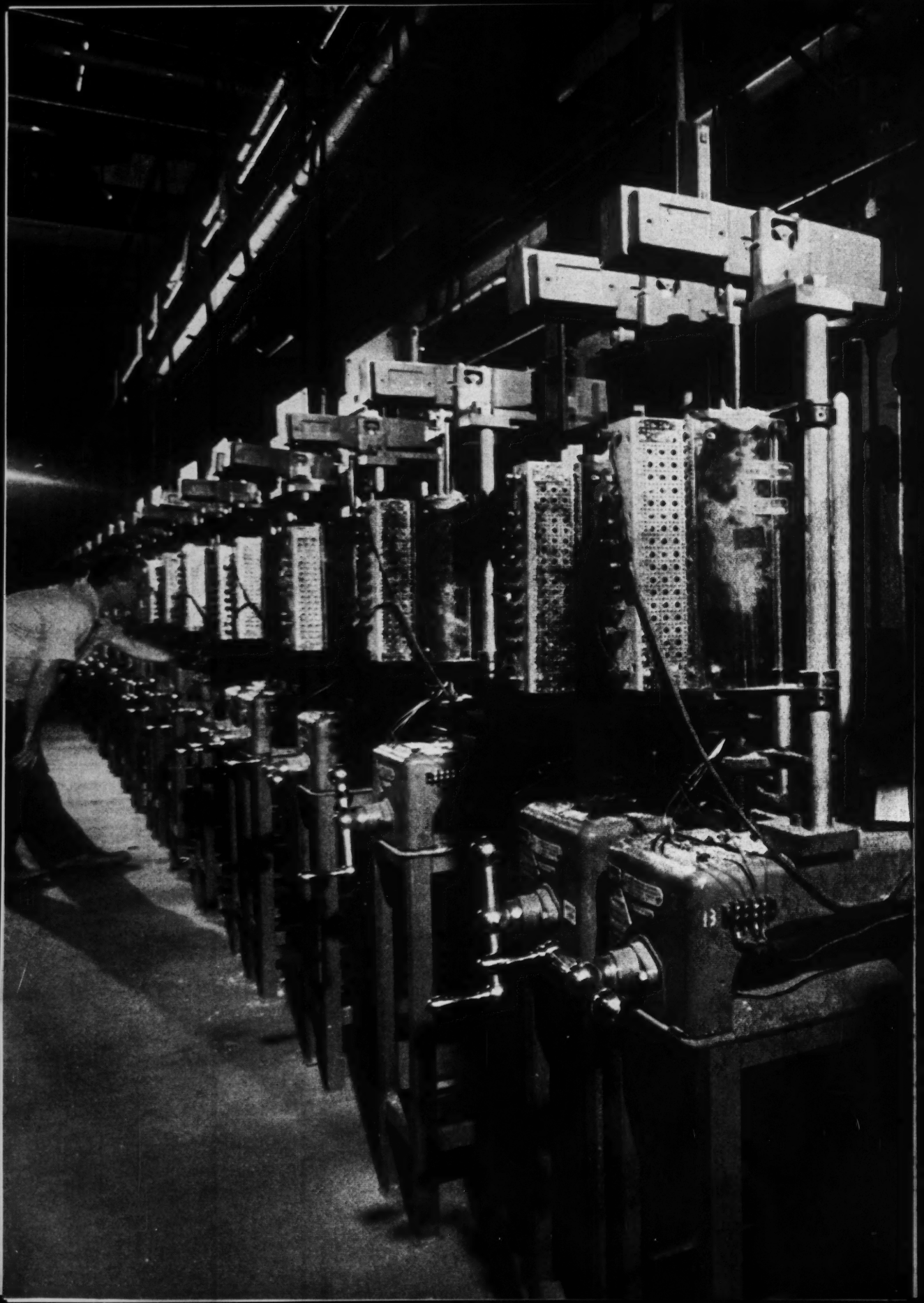
ENJAY® BUTYL

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY COMPANY, INC., *15 West 51st Street, New York 19, N.Y.*

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

For more information, turn to Reader Service card, circle No. 437



Every heat of every alloy proved on the spot

Stress-rupture testing at the Metals Division determines vacuum-induction-melted alloy life

After vacuum induction melting, every heat of every alloy produced at the Metals Division, Kelsey-Hayes Company, undergoes complete testing. Included in this evaluation is the all-important stress-rupture life test.

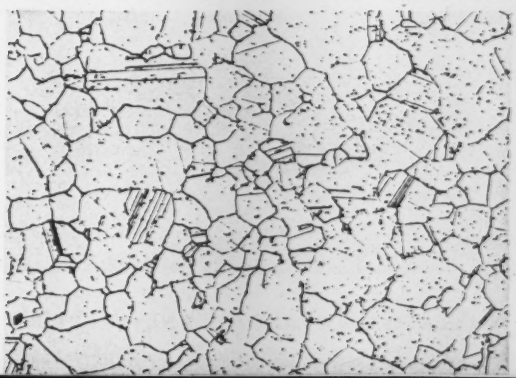
In a massive laboratory at Metals Division, over 100 mechanical property testing machines find the rupture point of alloys under given conditions of stress, time and temperature. For example, UDIMET 700, one of the latest alloy developments at Metals Division, has a stress-rupture life of 60 hours at 1800° F and 18,000 psi. UDIMET 500 and 41, Waspaloy, M-252 and many alloys are produced and similarly evaluated at the Metals Division.

Your superalloy requirements can benefit from Metals Division vacuum induction melting facilities and technical experience. Write Dept. 11, Metals Division, Kelsey-Hayes Company, New Hartford, N. Y., for full details.

METALS DIVISION
KELSEY-HAYES COMPANY
NEW HARTFORD, NEW YORK

For more information, circle No. 517

Over 100 stress testing machines (left) test high temperature properties of every alloy heat at Metals Division. Uniform grain structure and evenly distributed carbides contribute to remarkable stress-rupture life.



DOW

NEW MATERIALS GIVE PRODUCT PLANNERS FREE REIN

A few years ago, the management man with new products on his mind had to think of how to make them in terms of the limited choice of materials then available. Now, he first dreams up the desirable qualities his product should have, then selects the materials that meet these requirements. Plastics are one important reason for this big difference between yesteryear and today. Many different combinations of properties are available in plastics formulations and the selection grows wider every day. New developments in plastics materials, such as those reported below, provide plenty of ideas for new product planners.

NEW PLASTIC MAKES LUMINOUS CEILING IDEA COME TRUE

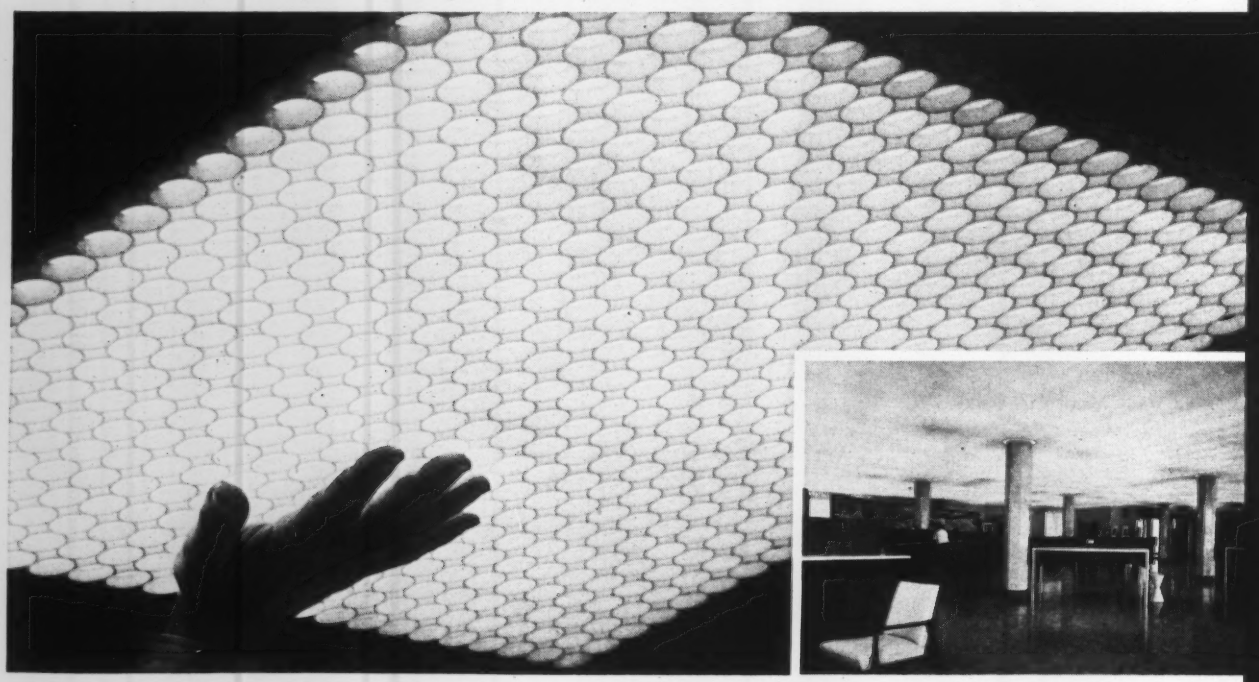
Unique suspended ceiling material made of Dow thermoplastic forms an unbroken luminous ceiling line, yields more light.

An architectural products manufacturer recently approached Dow with an idea for a new product. They knew exactly what they wanted, but knew of no material that would meet their requirements. They wished to manufacture a grid panel for use in suspended ceilings that would diffuse light to create the effect of a continuous luminous expanse of infinite dimension. The material they sought must be molded into intricate shapes, be dimensionally stable and have exceptional non-yellowing and light diffusing characteristics.

Fortunately, Dow was getting ready to introduce a new material that met these requirements perfectly. In a short time the manufacturer had his material and was in full production . . . an example of how manufacturers frequently find that the one right material for the job is already under development—or in production—at Dow.

This new material, called Styron® Verelite 672, was developed specifically for such applications. It possesses unique light transmitting and diffusing properties, and has an exceptionally high resistance to yellowing, a malady common to many materials under prolonged exposure to fluorescent light.

The grid panels, which fit together to form a continuous pattern for areas of any dimension, are finding extensive use as room dividers and display boards, as well as in ceilings. Light fixtures, sprinkler heads and other equipment can be installed above the ceiling level and thus be hidden from view.

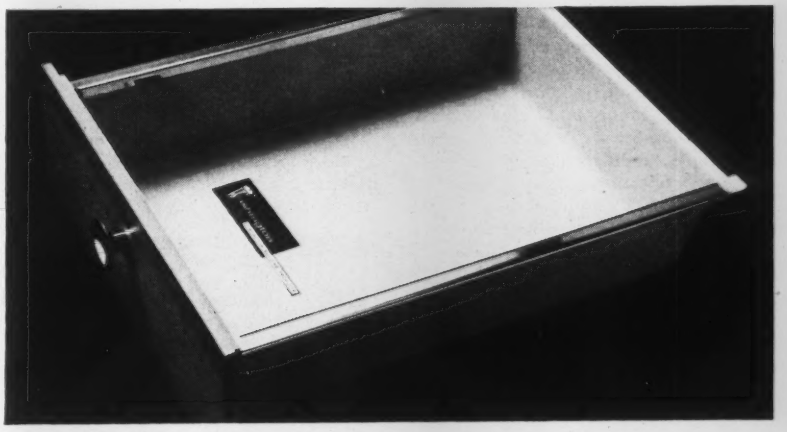


HARDHEADED SALES GAINER

When professional gridmen make and take those earth-shaking tackles their heads need all the protection they can get. That's why several pro teams equip their players with helmets made of lightweight, super-tough Ethocel®. Dubbed the "aristocrat" of all thermoplastics, high-impact Ethocel takes shock well over a wide temperature range. It has a high gloss and can be matched to many colors. Its excellent strength and molding characteristics permit large one-piece moldings for many rough and tumble applications.

THIS DRAWER WON'T WARP OR SPLINTER

This plastic drawer for the home is another example of creative engineering with Dow plastics in the building products field. Vacuum-formed of Styron® 475, it offers the last word in convenience and durability wherever built-ins are applicable. The manufacturer also supplies the glides and framing, leaving only the decorative exterior to be applied. The outstanding forming characteristics of Styron 475 keep production men happy. Rounded corners make the drawer easy to operate and easy to clean and, of course, it's splinter-free. It's long on looks as well as service life . . . cannot swell or warp because of the extremely low moisture absorption of Styron.



• • •

DON'T FREEZE THAT DESIGN until you've checked with Dow. Chances are, one of the many Dow thermoplastics will fit your materials requirements "to a tee". To find out, write today to THE DOW CHEMICAL COMPANY, Plastics Sales Department 1514CD11.

• • •

INDUSTRIAL MOLDING MATERIALS

•

PACKAGING MATERIALS

•

PAINT AND COATING MATERIALS

•

BUILDING PRODUCTS

THE DOW CHEMICAL COMPANY
Midland, Michigan

DOW

TWO MORE PRODUCT IMPROVEMENT IDEAS WITH DOW PLASTICS

STYRON
Great fun for the junior homemaker! This complete miniature washer-dryer contains several parts made of different Styron formulations. Properties demanded by this application include toughness, structural strength, smooth surface, clarity and resistance to soap chemicals. Styron also gives the production man a break with its excellent moldability.

PVC RESINS
These see-through tubes typify the many uses being made of formulations utilizing Dow PVC. The resulting high quality compound is then extruded into tubing, filled, sealed and crimped to make an attractive, low cost package. Two reasons Dow PVC is often selected: its high processing uniformity and resistance to many chemicals.

For more information, turn to Reader Service card, circle No. 434

The broad effect of CLAD-REX® on industrial design, engineering, and selection of materials

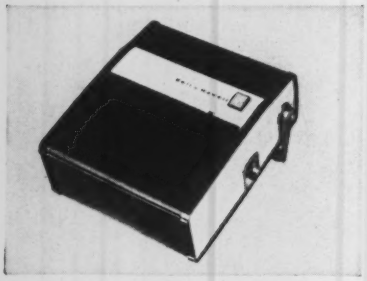
Reaction to the potential offered by vinyl-clad metals is contradictory. The potential advantage is so broad that it's hard to believe. But, when full realization does begin to develop, enthusiasm tends to go too far!

Therefore, your vinyl-clad metals data file should be assembled with care. Know exactly what you are considering, when to use it, and how.

Clad-Rex is a vinyl-metal laminate. Specifically, a calendered, semi-rigid poly-vinyl chloride film bonded to sheet metal. All alloys and tempers of aluminum and steel (including galvanized and aluminized) are commonly used. However, other metals can be used where their special properties are important to end product performance.

The sales appeal of Clad-Rex vinyl-metal laminate

The words *calendered* and *film* mean styling in Clad-Rex is unlimited, because film can be printed. Simulated wood-grains and leathers, as well as any color, combination of colors, texture or pattern can be used. Or you can design your own, if you prefer.



This unlimited choice ranges from sparkling burnishes including high metallics, to non-reflective matte finishes (or variations between) as well.

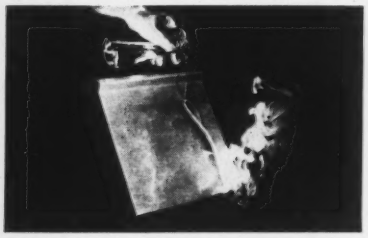
The abrasion resistance of Clad-Rex vinyl-metal laminates

The words *semi-rigid* and *poly-vinyl chloride film* mean Clad-Rex has unusual resistance to abrasion. Therefore, products made of Clad-Rex are more durable and suited to usage where abrasion resistance is required.

However—most important to manufacturing—Clad-Rex can be processed without the careful handling or rejects common to other pre-finished metals.

The corrosion resistance of Clad-Rex vinyl-metal laminates

The words *poly-vinyl* and *chloride* become important again, because of the inherent properties of the Clad-Rex vinyl. It provides excellent resistance

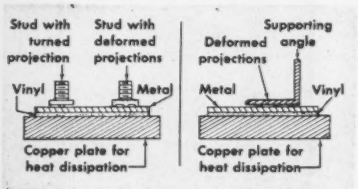


to acids and alkalis, as well as other corrosive chemicals. It also has high dielectric properties.

The fabrication of Clad-Rex vinyl-metal laminates

Clad-Rex can be formed in almost as many ways as any *un*finished sheet metal—including deep drawing!

Resistance welding, generally, is limited to projection techniques. However, the equipment must be (1) tooled for series welding (both electrodes on same side of sheet), and (2) capable of very short weld times with extremely fast follow-up of forging pressure.



Epoxy resins are proving quite successful for assembly. Clamps can be eliminated by using resistance weld tacking or interlocking design.

The cost advantage of Clad-Rex vinyl-metal laminates

As a purchased material going into a user's plant, vinyl-metal laminates cost more than *un*finished or some other pre-finished metals. *But, most important, end products made of Clad-Rex generally cost less!* Here's why:

(1) Parts made of Clad-Rex require no further finishing. This is a savings in equipment, finishing material, factory floor space, labor, handling, etc.

(2) The abrasion resistance of Clad-Rex substantially reduces (and often eliminates) rejects. This includes both rejected products *and* the expensive handling, reworking activities, and labor required.

Movement of sub-assemblies, etc., through your plant actually becomes more direct—out of your dies into assembly!

A source of engineering and manufacturing service for you

Clad-Rex interest in helping you extends into your own plant. A Clad-Rex Fabricating Engineer is provided to show your production people how easy it is to process Clad-Rex.

Furthermore, Clad-Rex operates a fully staffed and equipped research laboratory. Its facilities are devoted to customer service as well as improving Clad-Rex itself.

Write and describe your product. See how Clad-Rex can work its broad effect on industrial design, engineering and selection of pre-finished metals in your product.

VINYL-METAL LAMINATES BY CLAD-REX, DIVISION OF SIMONIZ COMPANY

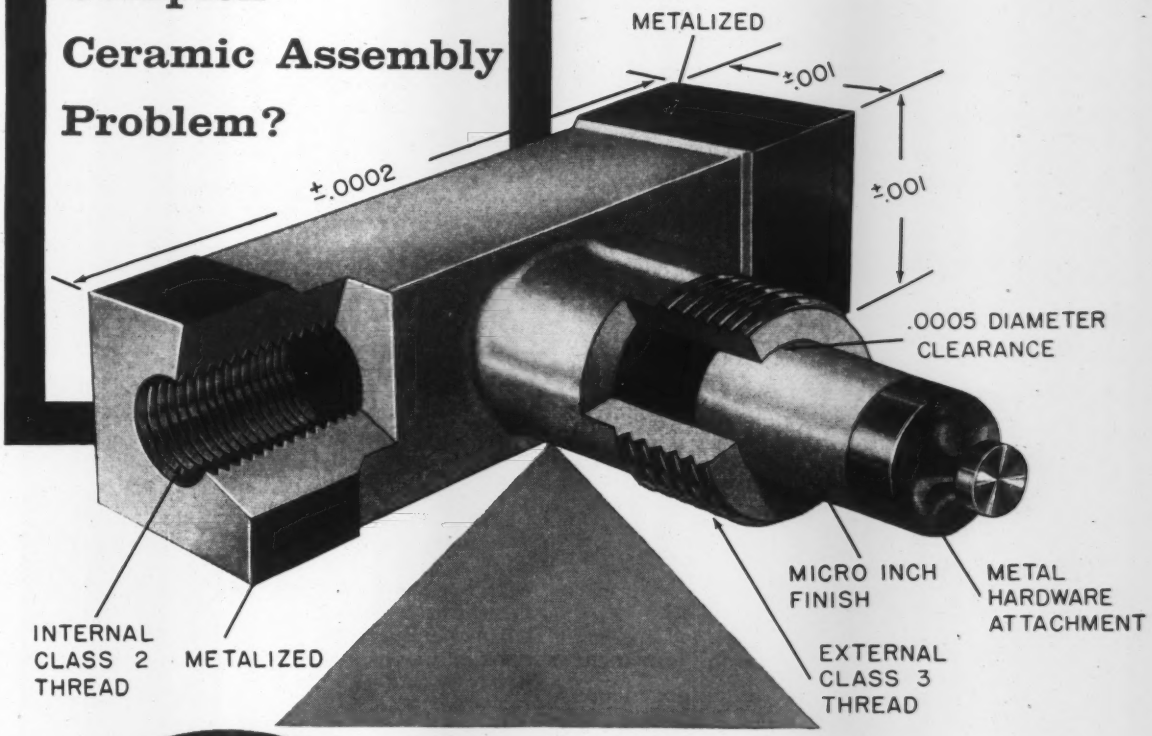
2109 Indiana Avenue • Chicago 16, Illinois

Telephone: VIctory 2-7272

4-BR

For more information, turn to Reader Service card, circle No. 542

Complex Ceramic Assembly Problem?



Centralab solves them daily

The pictured unit shows how CENTRALAB can control the manufacturing of precision ceramic-to-metal assemblies to extremely close tolerances, no matter how complex the shape, how intricate the machining. Let CENTRALAB design and production engineering help you take full advantage of the superior electrical and physical properties of High Alumina and Steatite ceramics.

You can achieve improved performance *and* eliminate production assembly problems by utilizing CENTRALAB's know-how in the specialized techniques of close tolerance ceramic-to-metal fabrication. CENTRALAB can handle complex, precision assemblies involving machining of ceramics or metals to ±.0002", metalizing of ceramics, cementing, riveting, soldering, plating, and stamping.

For detailed information on how High Alumina and Steatite ceramics can solve your electromechanical problems, write for free copy of CENTRALAB's new Ceramic Design Handbook (Bulletin No. 42-554), or consult Sweet's Product Design File (folio 4a/ce).

Centralab CRL®

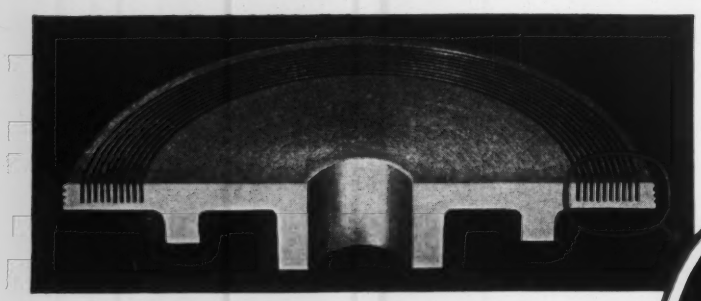
X-5970

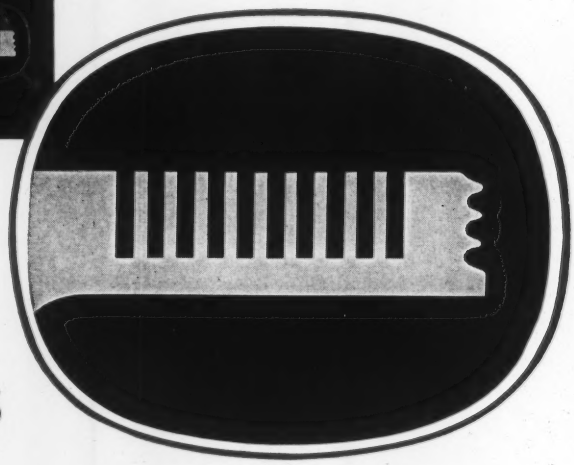
A DIVISION OF GLOBE-UNION INC.
946K E. KEEFE AVE. • MILWAUKEE 1, WISCONSIN
In Canada: 669 Bayview Ave., Toronto 17, Ontario

VARIABLE RESISTORS • SWITCHES • CERAMIC CAPACITORS • PACKAGED ELECTRONIC CIRCUITS • ENGINEERED CERAMICS

For more information, turn to Reader Service card, circle No. 471

Do Your Castings Require Sharp Corners *Like These?*





The Denser Structure of EATON PERMANENT MOLD GRAY IRON CASTINGS

Permits the Machining of Precise Corners

The fine dispersion of graphite in Eaton Permanent Mold Iron and its dense, non-porous, homogeneous structure make it an ideal material for many difficult machining operations where accurate dimensional results and sharp corners are essential.

Because its superior structure permits the machining of extremely thin sections and has the ability to take a high surface finish, Eaton Permanent Mold Iron is recommended for such critical applications as bearing retainers, connecting rods, pulleys, carburetor bodies, valve bodies, and service valves.

If you have applications which require these exceptional characteristics, our engineers will be happy to work with you.

The part shown above required that 10 grooves, .023" wide and .125" deep, leaving 9 lands .015" wide, be rapidly and simultaneously machined. Eaton Permanent Mold Iron proved to be the ideal material—completely eliminating the problem of curling chips in the small grooves, and crumbling of lands during machining.

Check these Important Advantages:

- ★ **Dense, non-porous, homogeneous structure**
- ★ **Freedom from inclusions**
- ★ **Excellent tensile strength**
- ★ **Ability to take a high surface finish**
- ★ **Freedom from leakage under pressure**
- ★ **Intricately cored sections**
- ★ **Uniformity of castings**
- ★ **Higher machining feeds and speeds**
- ★ **Substantially increased tool life**

Send for Illustrated Descriptive Literature

EATON MANUFACTURING COMPANY — *FOUNDRY DIVISION* — VASSAR, MICHIGAN

PRODUCTS: Engine Valves •Tappets •Hydraulic Valve Lifters •Valve Seat Inserts •Jet Engine Parts •Hydraulic Pumps Motor Truck Axles • Permanent Mold Gray Iron Castings • Forgings • Heater-Defroster Units • Automotive Air Conditioning Fastening Devices •Cold Drawn Steel •Stampings •Gears •Leaf and Coil Springs •Dynamatic Drives, Brakes, Dynamometers

For more information, turn to Reader Service card, circle No. 435

GENERALLY AVAILABLE ROUND SIZES* (E. W. G.)

Size of Tubes	CARBON		STAINLESS
	Cold Rolled	Hot Rolled	
⅛			20-25
¼			16-25
⅜	14-22		16-25
½	14-22		14-25
⅝	13-22		14-25
¾	13-22	13-16	12-25
⅞	13-22	13-16	12-25
1	11-22	11-16	11-25
1⅛	11-22	11-16	11-25
1¼	11-22	11-16	11-25
1⅜	11-22	11-16	10-23
1½	11-20	10-16	10-23
1⅝	11-20	8-16	10-23
1¾	11-20	8-16	10-23
1⅞	11-20	7-16	10-23
2	11-20	6-16	9-23
2⅛	11-20	6-16	9-22
2¼	11-20	5-16	9-22
2⅜	11-18	5-16	8-22
2½	11-18	4-16	8-22
2⅝	11-18	4-16	8-21
2¾	11-18	4-16	8-21
2⅞	11-18	4-16	8-20
3	11-18	4-16	8-20
3⅛	11-18	3-16	8-20
3¼	11-18	3-16	8-20
3⅜	11-18	3-16	8-20
3½	11-18	3-16	8-20
3⅝	11-18	3-16	8-20
3¾	11-18	3-16	8-20
3⅞	11-18	3-16	8-20
4	11-18	3-16	8-20
4⅛	11-16	3-16	8-18
4¼	11-16	3-16	8-16
4⅜	11-16	3-16	8-16
4½	11-16	3-16	8-20
4⅝	11-16	3-16	8-18
4¾	11-16	3-16	8-18
4⅞	11-16	3-16	8-18
5	11-16	3-16	8-18
5½	11-16	3-16	—
6	11-16	3-16	9-20

*Intermediate sizes, also larger and smaller sizes and heavier walls are available. Square, rectangular and other tubing shapes are also available in peripheries from 1" to 20" inc.

CARBON GRADES

Grade Designation	Carbon %	Manganese %	Phosphorus % Max.	Sulphur % Max.
MT 1010	0.05/0.15	0.30/0.60	0.040	0.050
MT 1015	0.10/0.20	0.30/0.60	0.040	0.050
MT X1015	0.10/0.20	0.60/0.90	0.040	0.050
MT 1020	0.15/0.25	0.30/0.60	0.040	0.050
MT X1020	0.15/0.25	0.70/1.00	0.040	0.050

HIGH CARBON GRADES

Grade Designation	Carbon %	Manganese %	Phosphorus % Max.	Sulphur % Max.
C 1025	0.21/0.28	0.30/0.60	0.040	0.050
C 1026	0.21/0.28	0.60/0.90	0.040	0.050
C 1030	0.27/0.35	0.60/0.90	0.040	0.050
C 1035	0.31/0.39	0.60/0.90	0.040	0.050

STAINLESS STEEL PIPE SIZES

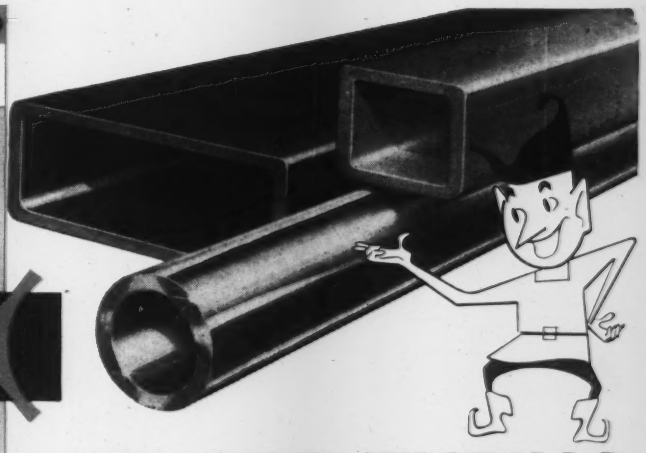
Stainless Steel Pipe Sizes are available from ⅛" I.P.S. through 2" I.P.S. in A.S.A. schedule 40S; from ⅛" I.P.S. through 4" I.P.S. in schedule 10S; and from ½" I.P.S. through 4" I.P.S. in schedule 5S wall thicknesses. Inquiries for larger diameters should be referred to a quality stainless steel pipe producer listed below.

STAINLESS GRADES

Type No.	Carbon (*)	Chromium	Nickel	Other Elements
302	.15	17-19	8-10	....
304	.08	18-20	8-12	....
304L	.03	18-20	8-12	....
309	.20	22-24	12-15	....
309S	.08	22-24	12-15	....
309SCB	.08	22-24	12-15	cb10XC Minimum—1 Maximum
310	.25	24-26	19-22	....
310S	.08	24-26	19-22	....
316	.08	16-18	10-14	Mo. 2-3
316L	.03	16-18	10-14	Mo. 2-3
317	.08	18-20	11-15	Mo. 3-4
321	.08	17-19	9-12	Ti 5 X C Minimum
329	.20	23-28	2½-5	Mo. 1-2
330	.15	14-16	33-36	....
347	.08	17-19	9-13	Cb-Ta 10 X C Minimum
348	.08	17-19	9-13	Cb-Ta 10 X C Minimum Ta .10 Maximum
430	.12	14-18	....	....
442	.20	18-23	....	....
443	.20	18-23	....	Cu .9-1.25

(*) Maximum—unless otherwise indicated.

LC-592



WELDED TUBING *offers*

- **THE SIZE**
- **THE GRADE**
- **THE SHAPE**

For a versatile tubular product, nothing equals Welded Steel Tubing. The quality producers offer a broad range of sizes and wall thicknesses in all weldable grades of carbon, stainless steel and other alloys. It is particularly adapted to shapes ranging from round, square and rectangular to the most complex special cross sections.

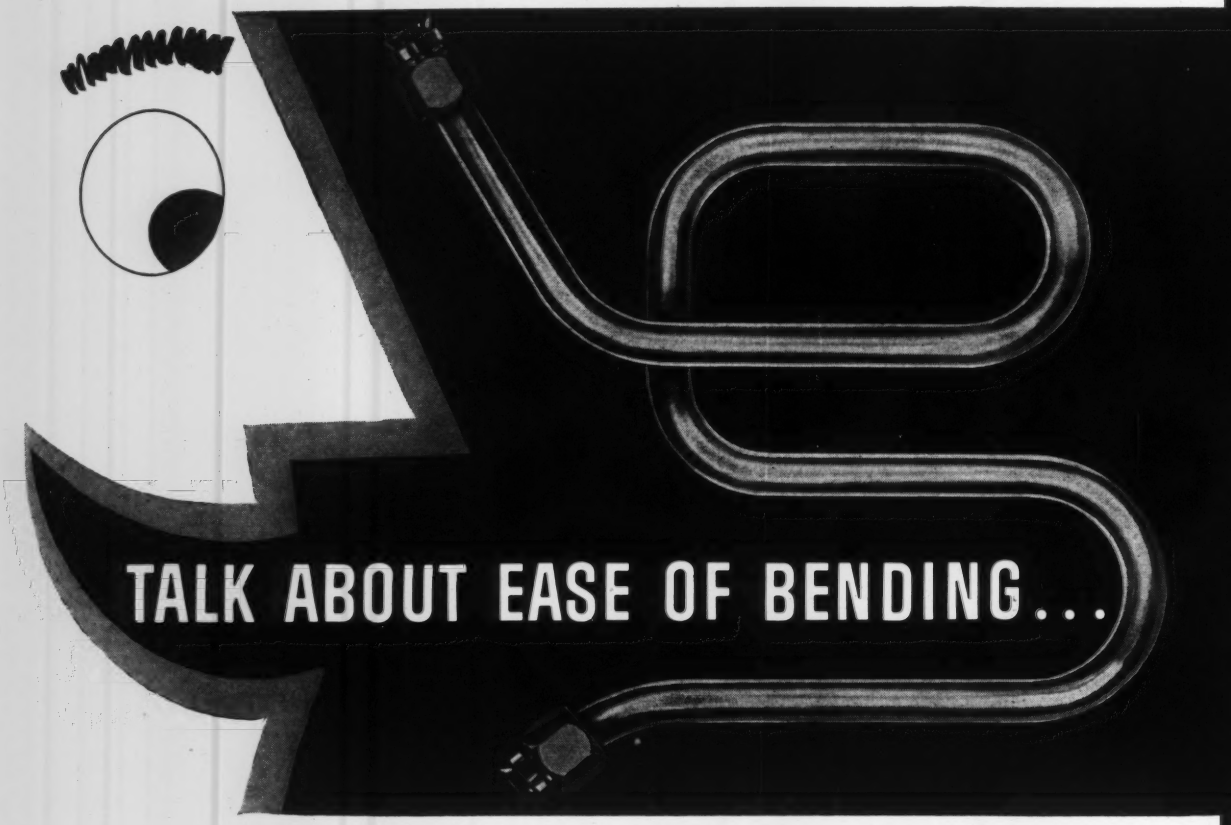
Welded Steel Tubing—as manufactured by the quality tube producers—offers a concise answer to most design problems. Specify Welded Tubing on your next order.

FORMED STEEL TUBE FSTI

850 HANNA BUILDING
CLEVELAND 15, OHIO

• Armco Steel Corp. • The Babcock & Wilcox Co., Tubular Products Div. • The Carpenter Steel Co., Alloy Tube Div. • Clayton Mark & Co. • Damascus Tube Co. • Jones & Laughlin Steel Corp., Electricweld Tube Div. • National Tube Div., United States Steel Corp. • Ohio Seamless Tube Div. of Copperweld Steel Co. • Republic Steel Corp., Steel and Tubes Div. • Revere Copper and Brass Inc., Rome Manufacturing Company Div. • Sawhill Tubular Products, Inc. • Southeastern Metals Co. • The Standard Tube Co. • Standard Tube and T. I. Ltd., (Canada) • Superior Tube Co. • Trent Tube Co., Subs. Crucible Steel Co. of America • Van Huffel Tube Corp. • Wall Tube & Metal Products Co.

For more information, turn to Reader Service card, circle No. 391



YOU SHOULD TRY ELECTRUNITE

The welded hydraulic fluid line tubing that offers lower initial cost... appreciable savings in downtime

The reason... uniformity! ELECTRUNITE Hydraulic Fluid Line Tubing is made from *high-grade, close-tolerance, flat-rolled* steel. Checked for defects as only flat rolled steel can be checked. Then: carefully formed, welded, annealed, cold-worked, and annealed again into a tube of unsurpassed uniformity... a tube that is easier to bend, easier to flare... a tube that meets or exceeds the normal life of tubing produced by any other method.

All this plus the fact that ELECTRUNITE costs *less* to buy (in all sizes shown in the *JIC Standards Book* and in an even wider range of sizes produced to our specification HL-1). Savings in downtime reflect still greater cost reductions. In the history of ELECTRUNITE Hydraulic Fluid Line Tubing, no failure resulting from longitudinal or transverse cracks has been reported.

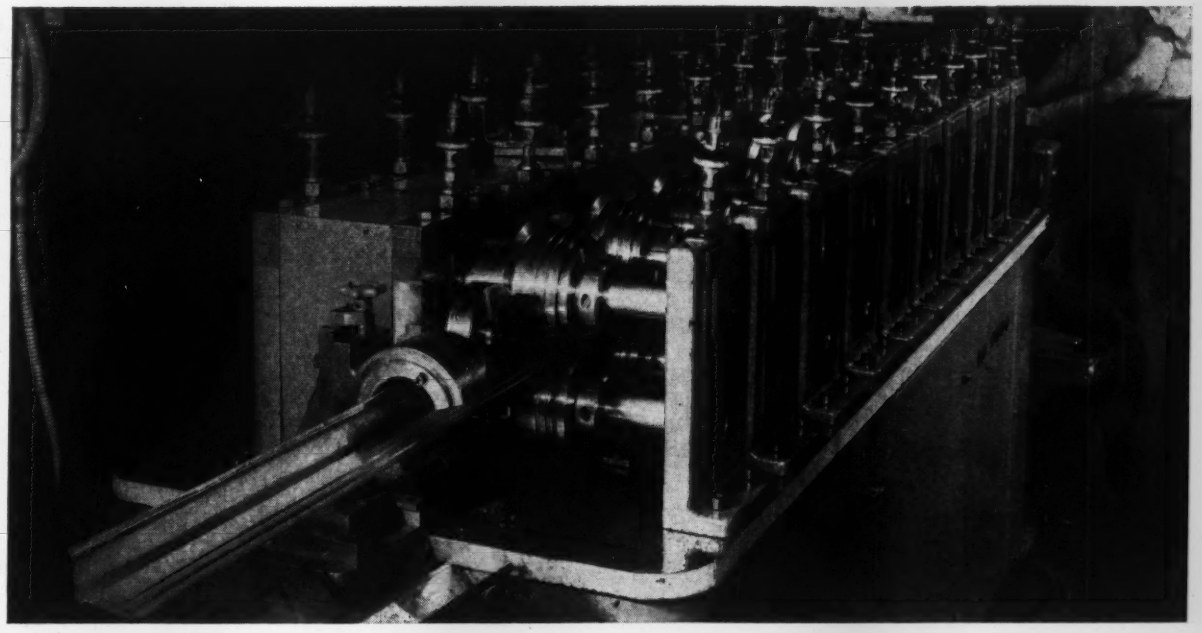
The big switch is on! Join the hundreds of equipment and machinery builders and their maintenance departments now using millions of feet of ELECTRUNITE Hydraulic Fluid Line Tubing. Mail the coupon for complete information, including a copy of specifications.

MEETS ALL REQUIREMENTS OF THE JIC STANDARD!

ELECTRUNITE® is available in all sizes shown in JIC Standards Book. Available in a wider range of sizes produced to our specification HL-1 (which meets all test requirements of the JIC standard).

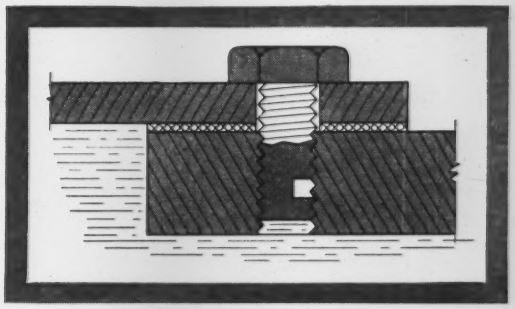
REPUBLIC

World's Widest Range of Standard Steels and



SAVE PAINT PREPARATION COSTS on your formed steel products by specifying Republic ELECTRO PAINTLOK®. Special paint-holding surface applied at our mills won't crack, flake, or peel—even under severe bending—as demonstrated by this acoustical panel forming operation. Final finish can be applied immediately, with excellent results. Mail coupon for complete information.

STAINLESS STEEL TUBING CUT COSTS for Cleveland Process Company, makers of immersion heaters. Brittle material originally used for casing of heating element was expensive, often cracked when scale was removed. Cleveland Process Company solved the problem by switching to Republic Stainless Steel Tubing. ELECTRUNITE® Stainless Tubing is strong, easy to fabricate, will save money in the long run. Send coupon for more information.



LIQUID SEALING PERFORMANCE is an added feature with Republic Self-Locking Nylok® Bolts. Nylon Pellet in compression tends to expand, effectively closing the space between non-loadbearing surfaces of mating threads. Fluid escape along helical thread path is blocked. Nylon pellet resists aging, moisture, and ordinary solvents. Send coupon for full information.

STEEL

Steel Products

REPUBLIC STEEL

REPUBLIC STEEL CORPORATION
DEPT.ME-8084-B
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send more information on:

- ☐ ELECTRUNITE Hydraulic Fluid Line Tubing, including a copy of specifications
- ☐ Stainless Steel Tubing
- ☐ Self-Locking Nylok Bolts
- ☐ Republic ELECTRO PAINTLOK

Name_____ Title_____

Firm_____

Address_____

City_____ Zone____ State_____

For more information, turn to Reader Service card, circle No. 369

THE PEOPLE WHO KNOW REFRIGERATION BEST

DEPEND ON THE PEOPLE WHO KNOW TUBING BEST!

THESE EXPERTS COOK UP WAYS TO MAKE SERPENTINES LIE FLAT AS PANCAKES!

Before a GM Steel Tubing serpentine can play a leading role in a condenser, it must pass this "profile" check. Here serpentines are checked for dimension—and are found to adhere more closely to your specifications. They are checked for flatness. And experience shows that because GM Steel Tubing is rotary-straightened, these serpentines lie flatter, can be retained better in wire-welding fixtures, and consequently speed up wire welding for more production. This is part of the General Motors Reliability you enjoy with GM Steel Tubing. Contact your GM Steel Tubing Sales Engineer, today. *Rochester Products Division of General Motors, Rochester, New York.*

SEE SWEET'S CATALOG 1a/Ro

GM STEEL TUBING
BY ROCHESTER PRODUCTS

AMERICA'S LARGEST MANUFACTURER OF REFRIGERATION TUBING

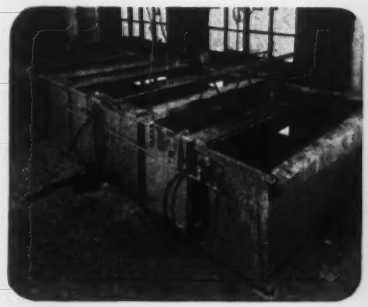
For more information, turn to Reader Service card, circle No. 480

Here are five ways to use versatile-flexible

TYGON®

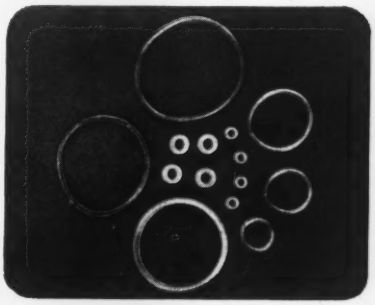
AS TUBING OR HOSE to pipe taste-sensitive liquid foods or corrosive chemicals. Tygon Tubing is glass-clear, flexible as a piece of string, resistant to acids and alkalies, non-toxic, sterilizable, and is made in bores from 1/16″ to 4″.

AS A PAINT to protect plant and equipment from attack by corrosive fumes and gases. Applied by brush or spray, Tygon air dries quickly to form a tough impermeable plastic skin that shrugs off acids, alkalies, oils, water and alcohols.



AS A HEAVY-DUTY LINING to protect the interior of pickling, plating, chemical processing and storage tanks from destruction by corrosive solutions. Easier to install than rubber linings, Tygon can be applied to tanks of any size or shape.

AS A CORROSION-RESISTANT GASKETING. Tygon shows no chemical deterioration with age. Gaskets remain flexible and tight, unaffected by weather or exposure to chemicals. Tygon gaskets are available in an almost unlimited size range.



AS MOLDED ITEMS. Tygon's toughness, durability and flexibility, coupled with staunch chemical resistance, offer pronounced performance characteristics for grommets, washers and molded mechanical goods items in virtually any shape.

Few materials offer more versatility in use than the Tygon series of thermoplastics. In whatever form they are used: tubing, coatings, sheet materials or molded goods, the Tygons are characterized by superb resistance to chemical attack. It shrugs off with equal ease both acids and alkalies. If corrosion is a problem in any product you make, Tygon may prove the perfect answer.

WRITE TODAY for the TYGON PORTFOLIO. *Pertinent data and technical characteristics of the various Tygon compounds to enable you to determine just how you can use Tygon most advantageously. Free, on request. Address Dept.* MM-1159

OUR 100th YEAR

PLASTICS AND SYNTHETICS DIVISION

U. S. STONEWARE

AKRON 9, OHIO

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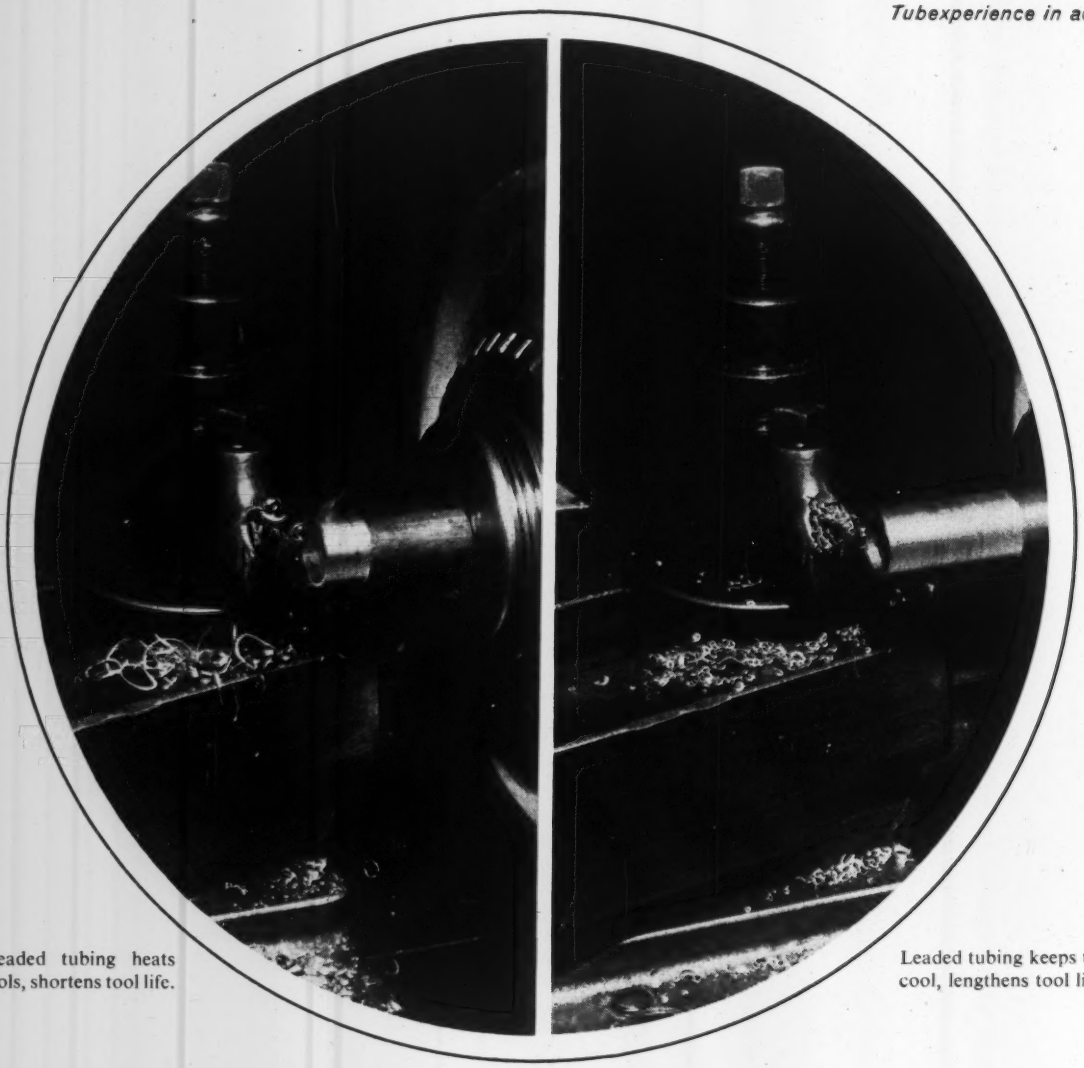
Tubexperience in action



Nonleaded tubing heats up tools, shortens tool life.

Leaded tubing keeps tools cool, lengthens tool life.

Now Superior Carbon Steel Tubing with Built-in Lubrication

New leaded 1020 tubing permits faster speeds and heavier feeds, often reduces the number of finishing operations

Where machinability is of major importance, specify Superior Seamless Leaded 1020 Tubing. Its built-in lubrication permits faster speeds in turning, drilling, tapping, milling, grinding and other machining operations, provides an 18% increase in feeds, and often reduces the number of finishing operations required to produce a smooth, lustrous surface. Build-up of metal at the cutting edge of the tool is minimized. Chip formation is improved. Tools operate at lower temperatures, last longer, and require fewer dressings. Lower tool cost is an accompanying benefit. Another is reduced downtime for replacement of dull and wornout tools. There is virtually no difference in physical and mechanical properties between leaded and nonleaded carbon steel tubing. So the grades are interchangeable.

Superior Seamless Leaded 1020 Tubing is available in a range of ODs from .012 through 1⅛ in. For particulars, send for Data Memorandum No. 24. And remember that other small-diameter tubing is available in more than 120 analyses, meeting a very broad range of applications. Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

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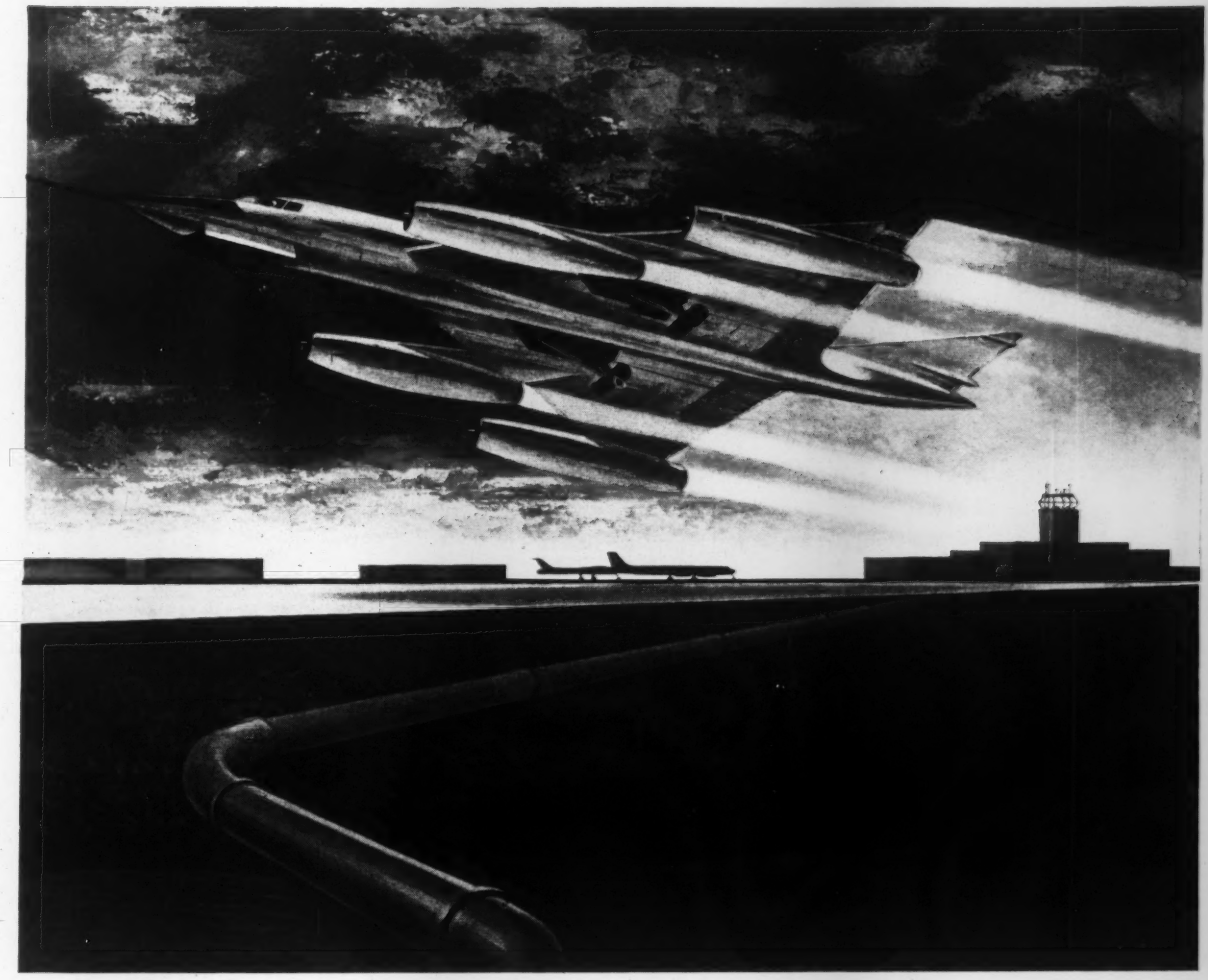

EPON® 828 . . . from TOP to BOTTOM,

the recognized performance standard for liquid epoxies

Ever since its introduction a decade ago, Shell Epon 828 has set the pace as a uniform thermosetting plastic with a remarkably wide range of applications . . . from high-flying missiles to underground glass fiber pipe and pipe coatings. No other resin polymer combines such outstanding uniformity with *so many* other desirable properties.

A pourable liquid at room temperature, Epon 828 is a 100 per cent reactive resin that gives unexcelled performance in wet lay-up laminating of glass fiber, in potting and encapsulating electronic components, in casting, and in surface coating. In adhesive formulations, Epon 828 makes extremely strong bonds with metal, wood, glass, and many plastics . . . stronger often than welds or rivets.

Epon 828 is used in the manufacture of many products, new and old, such as boats, tools and dies, aircraft, commercial adhesives, and vinyl stabilizers. It is a principal ingredient in surface coating formulations that give films of almost unparalleled resistance to abrasion, impact and the attack of solvents, alkalis, and acids. A new and fast-growing use is in industrial floor surfacing compounds.

* * *

The unequalled uniformity of Epon 828 assures formulators of this wide range of applications. Only Shell Chemical offers you a *complete* line of epoxies. Write to your nearest Shell Chemical district office.

Epon puts the power in plastics

SHELL CHEMICAL CORPORATION

PLASTICS AND RESINS DIVISION

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Chicago 48, Illinois	Cleveland 14, Ohio	New York 20, New York	Downey, California

IN CANADA: Chemical Division, Shell Oil Company of Canada, Limited, Toronto

SHELL

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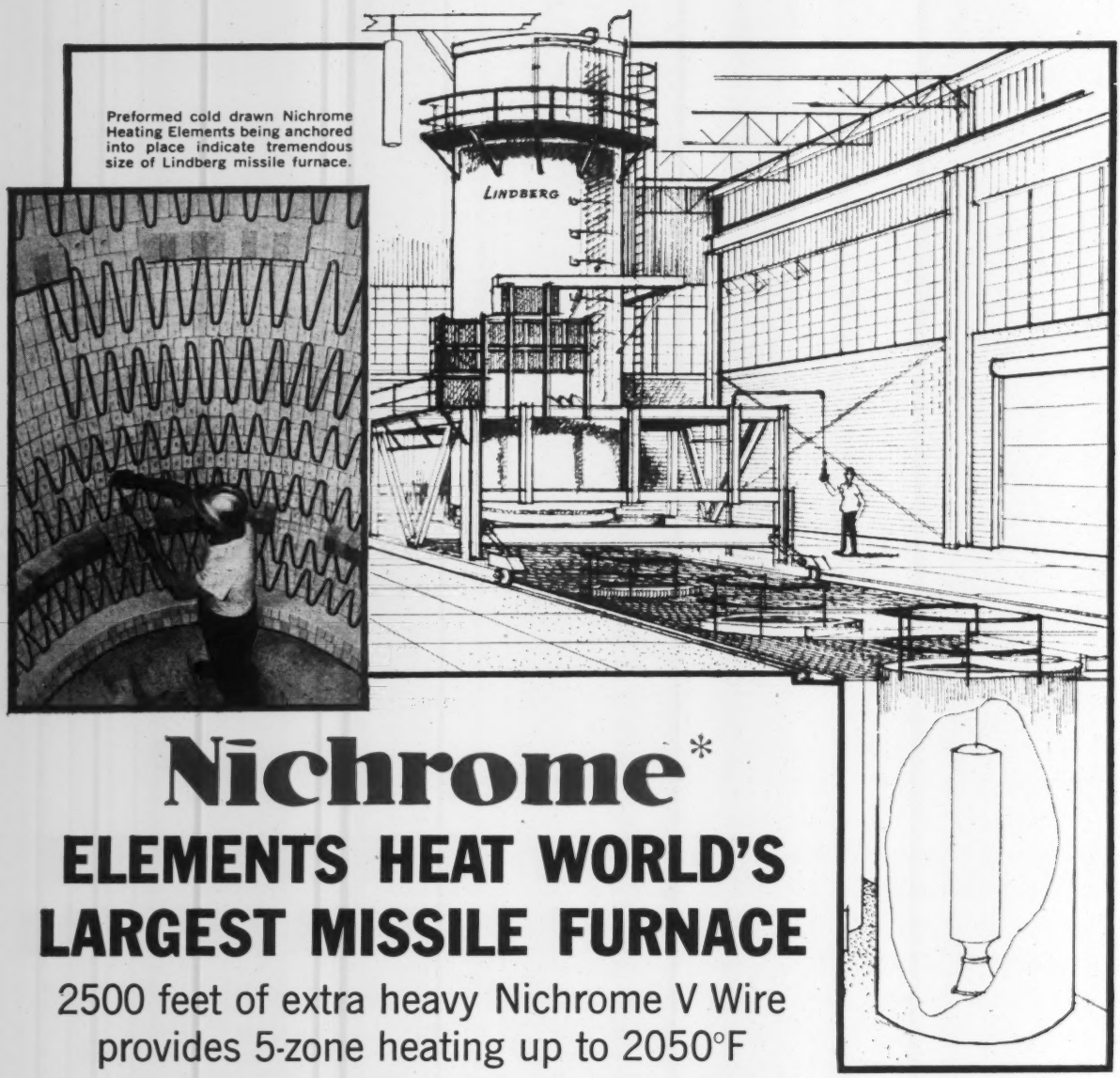

Preformed cold drawn Nichrome Heating Elements being anchored into place indicate tremendous size of Lindberg missile furnace.

Nichrome*

ELEMENTS HEAT WORLD'S LARGEST MISSILE FURNACE

2500 feet of extra heavy Nichrome V Wire provides 5-zone heating up to 2050°F

This giant 500 KW gantry type Lindberg† hardening furnace is the newest and largest ever built to meet the most exacting heat treating requirements of today's, and tomorrow's, missile metals. It accommodates an effective work load nearly 7 ft. in diameter and 24 ft. long.

Now in operation at Lindberg Steel Treating Company's Melrose Park Plant, the controlled atmosphere installation is both bottom loading and bottom quenching. The 19′ by 57′ pit—28′ deep, beneath the towering electrically heated furnace, houses the loading station, 2 quench tanks (atmosphere and salt) and water wash tank. Work loads pass from furnace to quench through an airtight seal, permitting complete control and precise duplication of atmospheres and treating cycles.

In the hardening furnace there are five control zones which operate between 250°F and 2050°F. Saturable core reactors automatically vary the voltage to the Nichrome*V heating elements between 2.2 and 220 volts, depending on temperature and load.

The selection of Nichrome V by Lindberg to supply reliable and closely controlled heat and temperature in this furnace is further evidence of the confidence that industrial leaders have in the quality and performance of Driver-Harris high-nickel alloys. Why not benefit from their experience. Tell us about your requirements. *T.M. Reg. U.S. Pat. Off. †Lindberg Engineering Company

DRIVER-HARRIS* COMPANY

HARRISON, NEW JERSEY • BRANCHES: Chicago, Detroit, Cleveland, Louisville

Distributor: ANGUS-CAMPBELL, INC., Los Angeles, San Francisco • In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario

MAKERS OF THE MOST COMPLETE LINE OF ALLOYS FOR THE ELECTRICAL, ELECTRONIC, AND HEAT-TREATING INDUSTRIES

SPECIAL PURPOSE ALLOYS SINCE 1888 — TRADE MARK REG. U.S. PAT. OFF.

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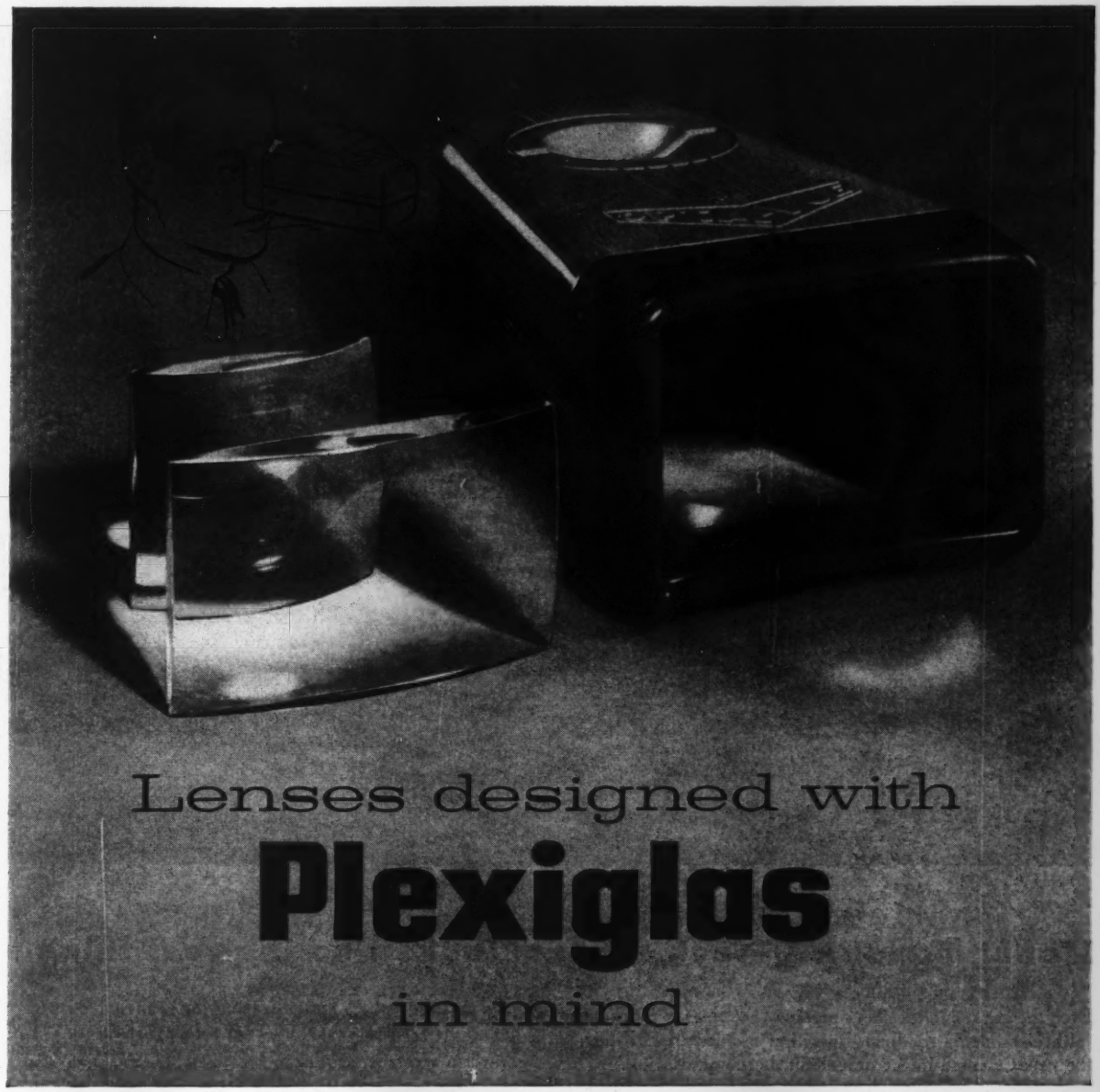

Problem. Design of a magnifying lens system for 35mm slide viewer*.

Requirements. Five-times enlargement of slide picture with clarity, sharpness and freedom from distortion. Lens system to be resistant to impact if viewer is dropped. Viewer to be priced within range of single-lens units.

Solution. Dual lens system, with lenses molded of optical grade PLEXIGLAS® acrylic plastic. Use of PLEXIGLAS resulted in lenses that give excellent performance and are highly resistant to breakage. Because lenses could be *molded* precisely to fine tolerances, considerable production cost savings were achieved through elimination of lengthy grinding and polishing operations required for glass lenses.

*"Opta-Vue", by Optics Mfg. Corp., Philadelphia 34, Pa.

Examples of fine quality molded parts made of PLEXIGLAS, *in many fields of use, are shown in our full color brochure,* "PLEXIGLAS *for Molded Parts". We will be pleased to send you a copy.*

Chemicals for Industry

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

In Canada: *Rohm & Haas Co. of Canada, Ltd., West Hill*
Crystal Glass & Plastics, Ltd., Toronto

For more information, turn to Reader Service card, circle No. 394

Lionel Model RR Track System looks like the real thing

Even the grain and the check marks of the ties are reproduced faithfully in this roadbed—injection molded in Fortiflex, the new Celanese linear polyolefin thermoplastic.

Although rigid and form retentive, Fortiflex contributes sound deadening properties that virtually eliminate the need for acoustical padding.

Fortiflex is now available in two types: A and B—in a number of melt indexes to meet the specifications of a variety of end use applications. For more information or test quantities, return coupon.

Celanese® Fortiflex®

TYPICAL PHYSICAL AND CHEMICAL PROPERTIES OF FORTIFLEX

Properties of Fortiflex "A" Related to Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	FORTIFLEX RESINS A-20	A-70	A-250	A-500
Melt Index	D-1238-52T	—	0.2	0.7	2.5	5.0
Heat Distortion Temp. (66 psi)	D-648-45T	°F.	185	185	180	180
Brittleness Temp.	D-764-52T	°F.	—200	—180	—160	—100
Impact Strength, izod (⅛" x ½" injection-molded bars)	D-256-54T	ft. lb./in. notch	23	18	13	3
Tensile Strength, Max., 0.2 in./min.	D-638-52T	psi.	3700	3600	3500	3300
Elongation, First Tensile Yield Point	D-638-52T	%	25	25	25	25

Properties of Fortiflex "A" Not Affected by Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	VALUE
Density		g/cc.	0.96
Refractive Index	D-542-50	n_D^{25}	1.54
Hardness, Shore D	D-676-49T		65
Stiffness	D-747-50	psi.	150,000
Water Absorption (⅛" specimen, 24 hr. immersion @ room temp.)	D-570-54T	%, wgt. gain	<0.01
Flammability	D-635-44	in./min.	1.0
*Mold Shrinkage, length		in./in.	0.03 to 0.05
width		in./in.	0.02 to 0.04

*Measured on injection molded tensile bar. Mold shrinkage depends on part design and molding conditions.

Fortiflex...a Celanese plastic

Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, N Y. 16

Celanese Corporation of America, Plastics Division,
Dept. 102-K, 744 Broad Street, Newark 2, N. J.

Please send: ☐ more information on, ☐ test quantities of Fortiflex.

Name _____ Title _____

Company _____

Address _____

City _____ State _____

DESIGNED IN CELANESE FORTIFLEX...

CONTAINER FOR VAPORIZER
Molded in Fortiflex for General Electric, Bridgeport, Conn.
by Air Formed Products Corporation, Nashua, N. H.

Blow molded plastic puts steam in vaporizer design

Sometimes a material and a process make a natural team —as in the case of Fortiflex linear polyethylene and blow molding. Together, they make it possible to redesign products for better quality and greater economy.

In this blow molded bottle for the new G.E. Vaporizer, Celanese Fortiflex (a non-conductor) provides added insurance against shorting of the electrical element and contributes to safer operation. Fortiflex withstands boiling temperatures without softening. The blow molding method makes it possible to produce this difficult shape quickly and economically in large scale production. Mold costs are substantially reduced. With a capacity of nearly a gallon, the bottle weighs little more than 12 ounces and provides steam for 12 hours without refilling. Molded-in bottle colors are pink and blue.

If you need a hollow component that has good strength, why not see whether a blow molding of Fortiflex will meet the requirements? We'll be glad to send you information on both process and material.

Celanese® Fortiflex®

Fortiflex...a Celanese plastic

Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver.
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, N.Y. 16.

For more information, turn to Reader Service card, circle No. 512

TYPICAL PHYSICAL AND CHEMICAL PROPERTIES OF FORTIFLEX

Properties of Fortiflex "A" Related to Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	FORTIFLEX RESINS A-20	A-70	A-250	A-300
Melt Index	D-1238-52T	—	0.2	0.7	2.5	5.0
Heat Distortion Temp. (66 psi)	D-648-45T	°F.	185	185	180	180
Brittleness Temp.	D-764-52T	°F.	—200	—180	—160	—100
Impact Strength, Izod (½" x ½" injection-molded bars)	D-256-54T	ft. lb./in. notch	23	18	13	3
Tensile Strength, Max., 0.2 in./min.	D-638-52T	psi.	3700	3600	3500	3300
Elongation, First Tensile Yield Point	D-638-52T	%	25	25	25	25

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Hardness, Shore D	D-676-49T		65
Stiffness	D-747-50	psi.	150,000
Water Absorption (⅛" specimen, 24 hr. immersion @ room temp.)	D-570-54T	%, wgt. gain	<0.01
Flammability	D-635-44	in./min.	1.0
*Mold Shrinkage, length		in./in.	0.03 to 0.05
width		in./in.	0.02 to 0.04

Measured on injection molded tensile bar. Mold shrinkage depends on part design and molding conditions.

Celanese Corporation of America, Plastics Division,
Dept. 202-K, 744 Broad Street, Newark 2, N. J.
Please send: ☐ more information on, ☐ test quantities of Fortiflex.

Name _____ Title _____

Company _____

Address _____

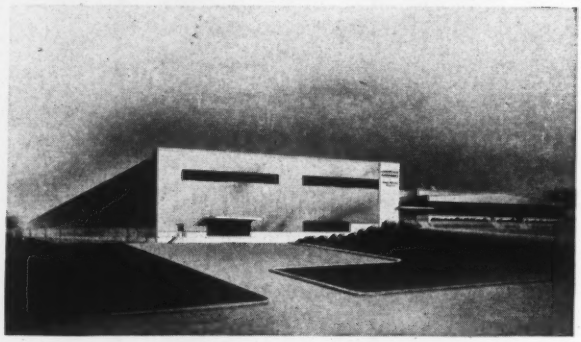
City _____ State _____

GOLD-CLAD STAINLESS TUBING CURBS CORROSION IN REACTOR

Photo pictures insertion of gold-clad stainless steel heat exchanger into gold-clad power reactor at AEC's Los Alamos Scientific Laboratory. Completely successful in recent operational tests, the unique reactor is designed to produce superheated steam in a single pass. This is the second experimental reactor using uranyl phosphate fuel—the first unit failed because of excessive corrosion in the heat exchanger. Gold-cladding now protects all structural parts in contact with the extremely corrosive solution.

Will clad metals solve *your* corrosion problems? Investigate the BISHOP line of clad metals. BISHOP was the first company to successfully produce gold-clad stainless tubing . . . coupon brings data. Use it.

NEW BISHOP TUBE MILL OPENS



Sketch shows new BISHOP facilities adjacent to the present tube mill in East Whiteland Township, west of Paoli, Penna.—completing the first stage in BISHOP's long range expansion program. This two-story structure will contain over 165,000 square feet of floor space. BISHOP platinum mechanical manufacturing operations also move to the East Whiteland plant.

BISHOP NOW DRAWING .002" WALL TANTALUM TUBING

Tantalum tubing with paper-thin wall thicknesses is now being supplied by BISHOP on special order. Sizes range from .062 in. OD x .002 in. wall to 1.5 in. OD x .125 in. wall. Columbium (niobium) tubing down to .002 in. wall has been produced and is also available. Can tubing of these "exotic" metals be the answer to any of your design problems? Check with BISHOP . . . use the coupon.

J. BISHOP & CO.

platinum works

FOR HELPFUL DATA USE THIS HANDY COUPON

- ☐ Tubular Products Bulletin No. 12
- ☐ Platinum Products Catalog No. 4
- ☐ Clad Metal Data
- ☐ Special Tubing Data

Check information you'd like and mail to
J. BISHOP & CO.,
40 King St., Malvern, Penna.

Name _____
Position _____
Company _____
Address _____
City _____ Zone _____ State _____

Tubular Products Division

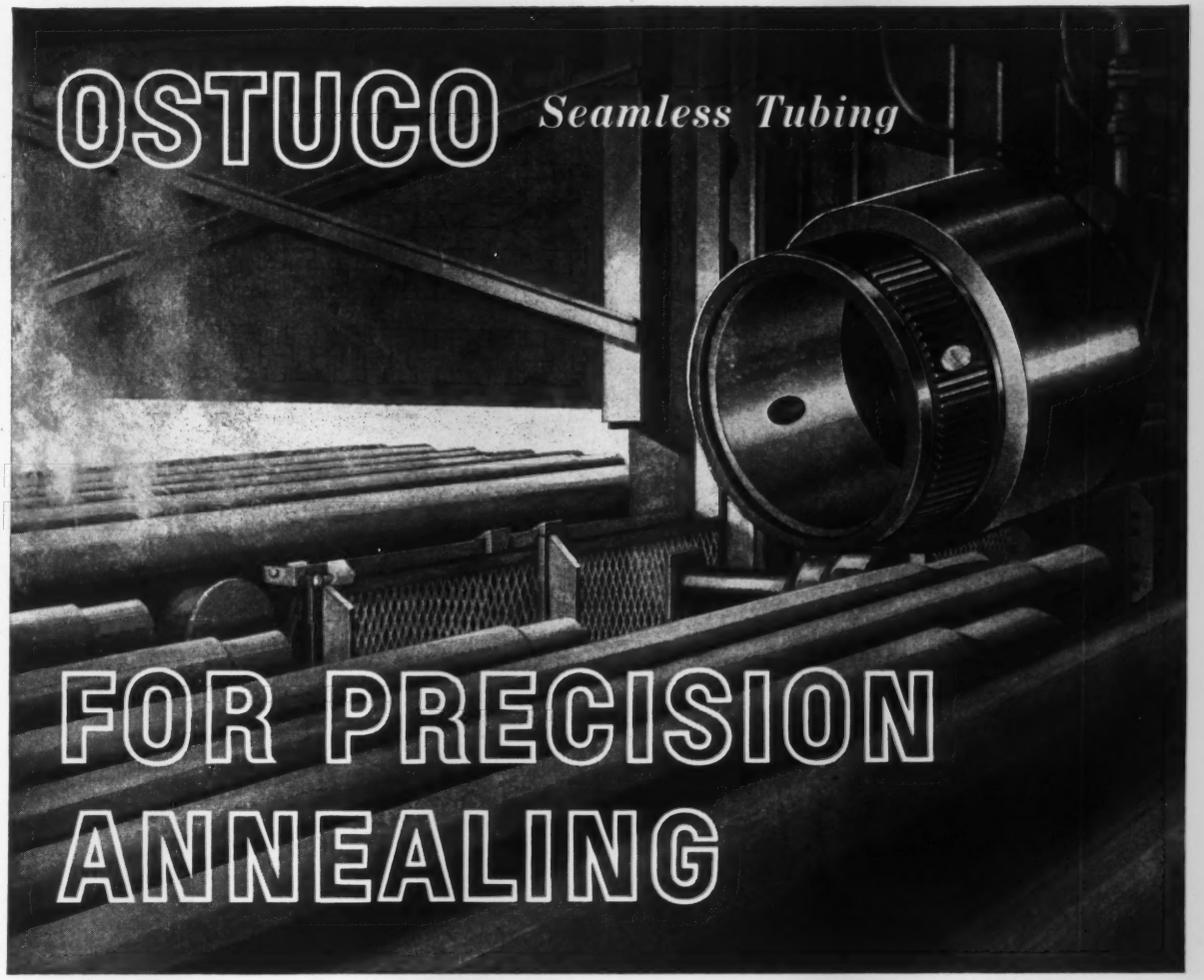
40 KING STREET, MALVERN, PENNA.

NIagara 4-3100

THIS IS THE BISHOP LINE:
Products of all the Platinum Metals... Small diameter Stainless Steel, nickel and special alloy tubing

For more information, turn to Reader Service card, circle No. 457

Automatic Transmission Manufacturer Specifies



Annealing furnace at the Shelby mill. Ostuco tubing can be bright or soft annealed, stress relieved, normalized or heat treated.

"As a leading producer of quality transmission components, we can't leave anything to chance. Our design requirements, materials specifications and manufacturing processes are under the most stringent quality control standards. And we demand as much of our vendors.

"One sure way we have found to eliminate the unpredictable is to specify Ostuco Seamless Tubing. We know from experience we can rely on the precision annealing and unvarying quality of Ostuco tubing that slashes reject rates, helps us produce parts in quantity for profit . . ."

If you want to eliminate the unpredictable in your own plant, then it's time you called your local Ohio Seamless representative. He's listed in the Yellow Pages. Or contact the plant at *Shelby, Ohio —Birthplace of the Seamless Steel Tube Industry in America.*

AA-9804

OSTUCO SHELBY, OHIO — OSTUCO TUBING

OHIO SEAMLESS TUBE DIVISION

of Copperweld Steel Company • SHELBY, OHIO

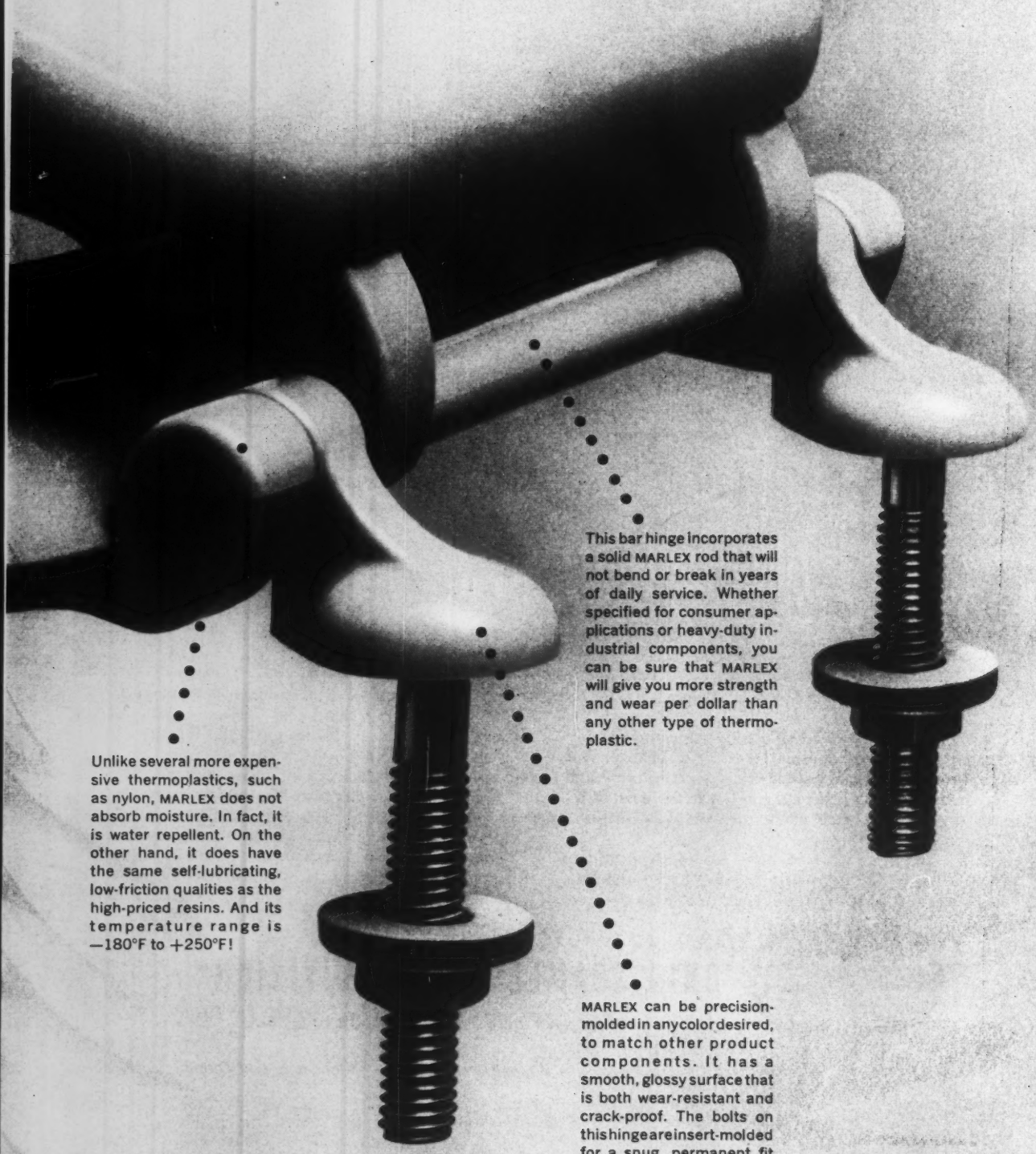
Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Los Angeles (Lynwood), Miami, Moline, New Orleans (Chalmette), New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Rochester, St. Louis, St. Paul, Salt Lake City, Seattle, Tulsa, Wichita CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 233 Broadway, New York 7, New York

For more information, turn to Reader Service card, circle No. 370

NEW DESIGNS IN MARLEX

C. F. Church selects . . .



This bar hinge incorporates a solid MARLEX rod that will not bend or break in years of daily service. Whether specified for consumer applications or heavy-duty industrial components, you can be sure that MARLEX will give you more strength and wear per dollar than any other type of thermoplastic.

Unlike several more expensive thermoplastics, such as nylon, MARLEX does not absorb moisture. In fact, it is water repellent. On the other hand, it does have the same self-lubricating, low-friction qualities as the high-priced resins. And its temperature range is −180°F to +250°F!

MARLEX can be precision-molded in any color desired, to match other product components. It has a smooth, glossy surface that is both wear-resistant and crack-proof. The bolts on this hinge are insert-molded for a snug, permanent fit that is strong and water-tight.

MARLEX®

for revolutionary new toilet seat hinge

C. F. Church picked MARLEX rigid polyethylene for this component because it combines economy with all of the qualities needed in a hinge of this type . . . toughness, unbreakability, resistance to corrosion and bacteria . . . self-lubrication, rigidity, hard glossy surface and colorability.

This new MARLEX hinge represents the first major improvement on the conventional brass bar hinge, which has been used by the plumbing industry for almost one hundred years.

Like so many manufacturers, the C. F. Church Division of American Standard recognizes that in MARLEX they have a material that can successfully replace metals, glass and wood, as well as more expensive plastics such as nylon, in thousands of component applications.

No other type of material serves so well and so economically in so many different applications. How can MARLEX serve you?

*MARLEX is a trademark for Phillips family of olefin polymers.

The designer of this new hinge is Sherwood L. Young, Vice President, Product Engineering & Development, at C. F. Church. Mr. Young stated that "after testing several different materials, MARLEX was chosen as it met our required specification for high strength with flexibility, *complete* corrosion resistance and built-in color. It also effected desirable savings in production costs."

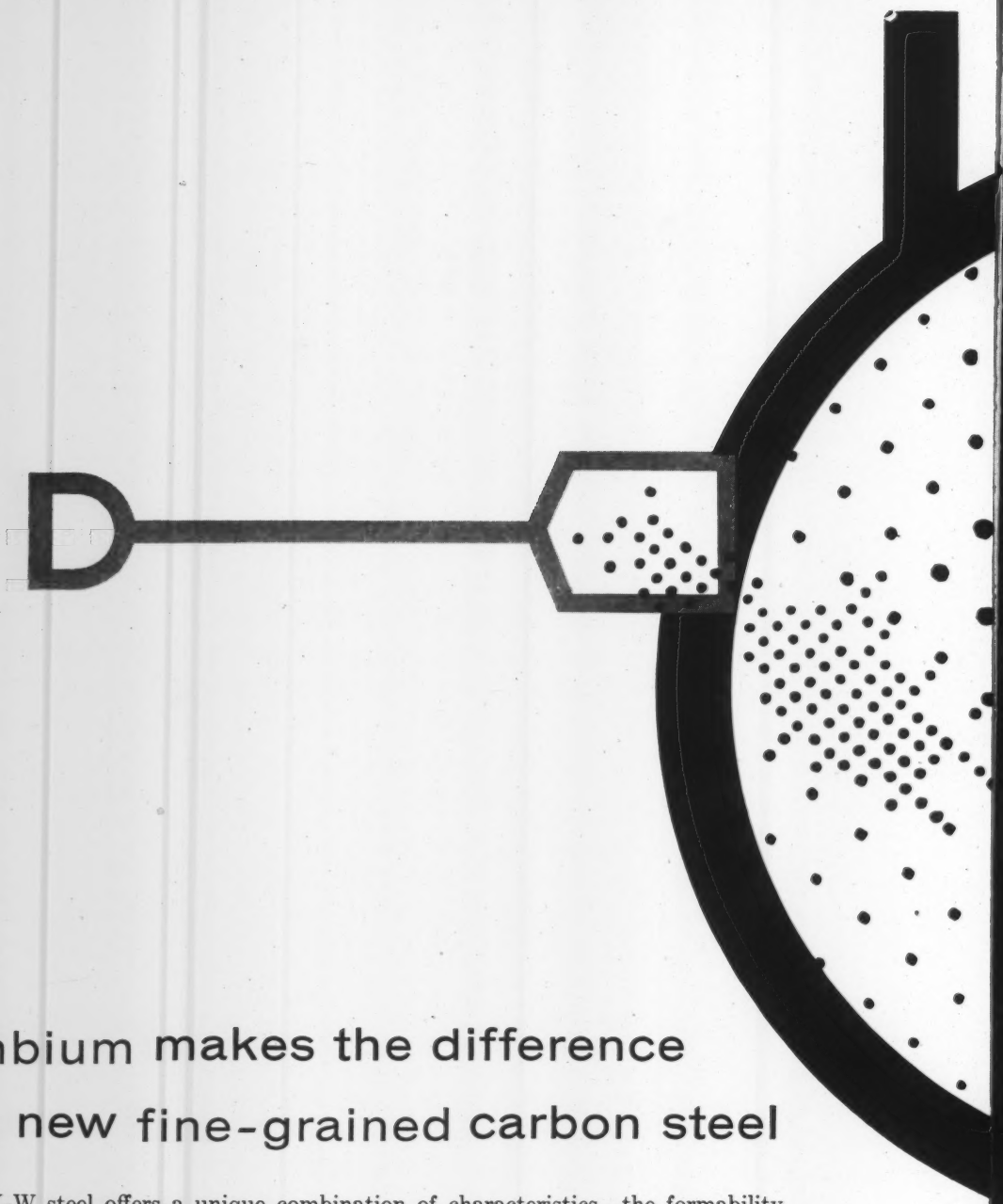
MARLEX
Phillips 66
A PHILLIPS 66 PLASTIC

PHILLIPS CHEMICAL COMPANY, Bartlesville, Oklahoma
A subsidiary of Phillips Petroleum Company

PLASTICS DIVISION OFFICES

NEW ENGLAND	NEW YORK	AKRON	CHICAGO	WESTERN	SOUTHERN	EXPORT
322 Waterman Avenue	80 Broadway, Suite 4300	318 Water Street	111 S. York Street	317 N. Lake Ave.	6010 Sherry Lane	80 Broadway Suite 2800
East Providence 14, R. I.	New York 5, N. Y.	Akron 8, Ohio	Elmhurst, Ill.	Pasadena 1, Calif.	Dallas 25, Texas	New York 5, N. Y.
GEneva 4-7600	Digby 4-3480	FRanklin 6-4126	TErrace 4-6600	MUrray 1-6997	EMerson 8-1358	Digby 4-3480

For more information, turn to Reader Service card, circle No. 442



Columbium makes the difference in this new fine-grained carbon steel

The new GLX-W steel offers a unique combination of characteristics—the formability and weldability of mild carbon steel *plus* greater tensile strength and notch toughness.

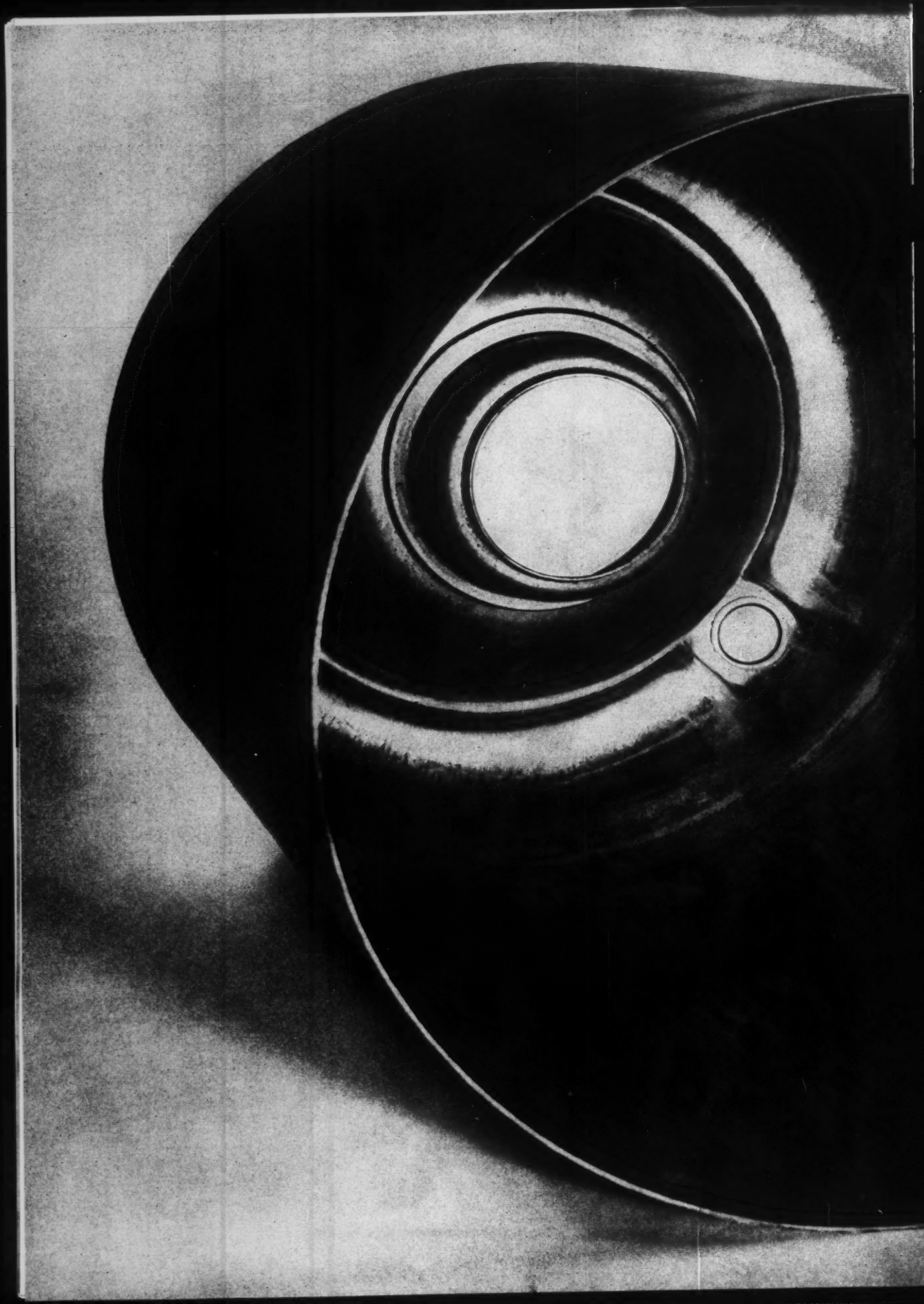
The addition of small amounts of columbium gives GLX-W the finer grain structure that makes this possible.

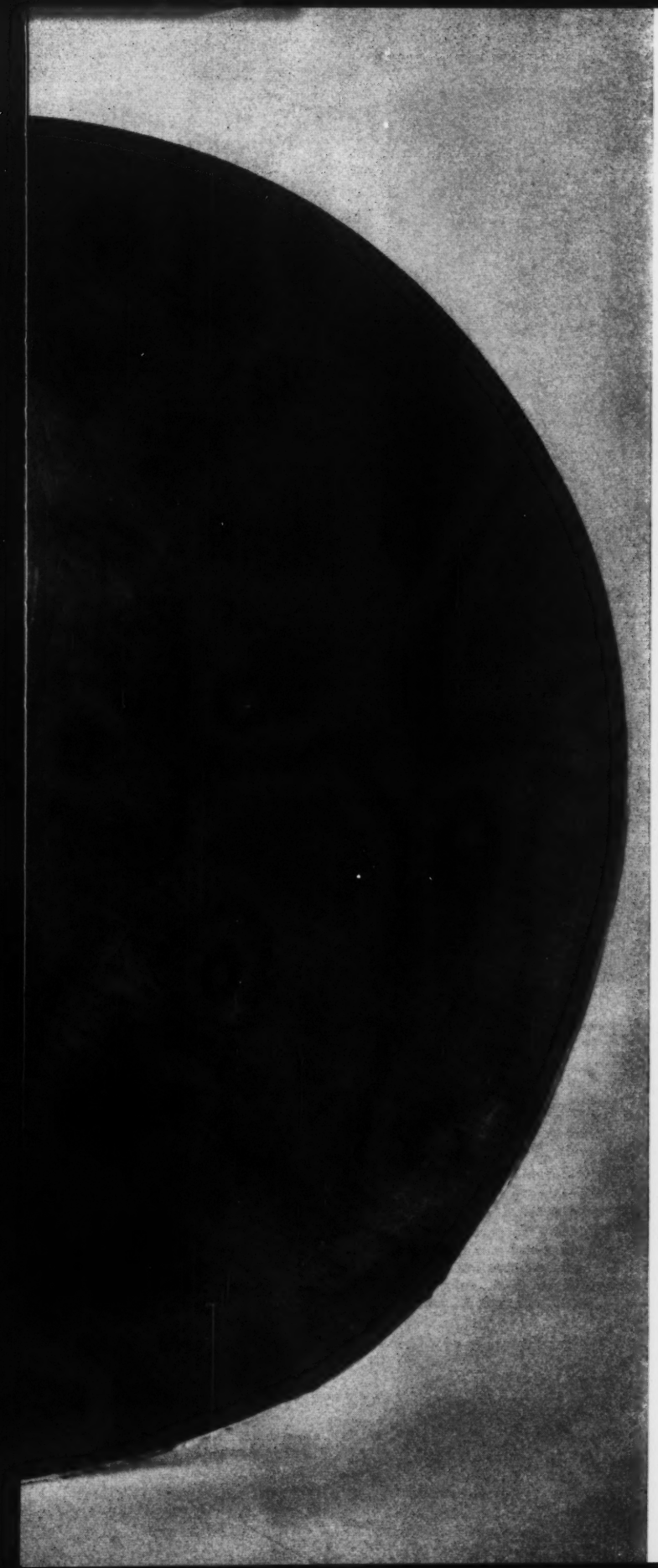
Where design permits, the use of GLX-W can result in weight savings up to 35%, compared with mild carbon steel. With yield strengths ranging from 45,000 to 60,000 psi, GLX-W steels are recommended for a broad range of applications. For technical information, write to our Product Development Division, Department D.

GREAT LAKES STEEL
Detroit 29, Michigan
A DIVISION OF NATIONAL STEEL CORPORATION

GLX-W

For more information, turn to Reader Service card, circle No. 420





Deep-Forming
USS Galvanized Steel Sheets
and the zinc stays on

The body and breast of this pressure spray tank is fabricated from one piece of 24-gage Galvanized Steel Sheet. A 20" circle blank is cut from the sheet. It is drawn 6½" deep and then reverse drawn to 11¾" deep by 7¾" wide—the finished size of the tank.

Standard Container, Inc., of Rockaway, New Jersey, selected USS Galvanized Steel for the tank because during the forming and punching operations, the zinc does not flake off the base metal. This remarkable adherence of zinc comes from the hot dip process of coating USS Galvanized Steel. The process makes a bond between zinc and base metal that is virtually inseparable. This, and the fine ductility of USS Galvanized Steel Sheets make them ideal for severe fabrication.

Give your product the added quality provided by USS Galvanized Steel Sheets. Contact your local U.S. Steel Sales Office or the steel warehouse serving your area.

USS is a registered trademark

United States Steel Corporation—Pittsburgh
American Steel & Wire—Cleveland
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel

FORMICA® field fabricating
Laminated Plastic

now...Streamliner service on fabricated parts

FIF

Fabricator of Industrial Formica laminated plastics

Formica® Field Fabricating better 3 ways:

1. Faster delivery on a totebox-ful or a truckload
2. Highest quality assured by fabricating specialists and modern equipment
3. 24-hr. delivery on standard Formica sheets and rods

Need a part fabricated quickly for prototype development? Need a truckload of parts to keep your production lines running? Call your local Fabricator of Industrial Formica laminated plastics. One or one million, he'll *fabricate and deliver* your Formica laminated plastic parts on a Streamliner schedule—within 24 hours in some cases.

He's located near you, offers more frequent contact. In many cases he stocks standard Formica sheets and rods for Streamliner delivery in a matter of hours.

The new Formica field fabricating service is without equal. It can save you time and money in more efficient parts procurement. Write us for complete information and the name of the fabricator nearest you. Formica Corporation, subsidiary of American Cyanamid, 4550 Spring Grove Ave., Cincinnati 32, Ohio.

FORMICA® Laminated Plastic *a product of* CYANAMID

FI-2076

For more information, turn to Reader Service card, circle No. 461

For more information, circle No. 516 ➤

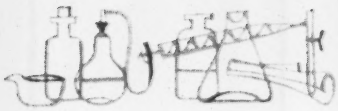
THE BEAUTY OF utility

The Stainless Steel products illustrated are made by STEELEX Corporation, Williamsport, Pa.

in Superior Stainless STRIP STEEL

SERVICE-ABLE Superior Stainless performs handsomely in these functional utensils—always bright, easy to clean, with extra strength for extra years of use. • Superior Stainless delivers handsome performance in fabrication, too . . . handles *right* because of superior quality control at every stage of manufacture. • We have much to offer in technical assistance. Write us on your stainless applications.

SUPERIOR STEEL DIVISION
OF
COPPERWELD STEEL COMPANY
CARNEGIE, PENNSYLVANIA
For Export: Copperweld Steel International Company, New York



Hundreds of custom molders of plastics have no research and development facilities . . .

Some have one or two men . . .

But only one is staffed for every type of plastics research and development . . .

GENERAL AMERICAN

Plastics Division

General American's Plastics Division offers you advantages no other molder in the world can match!

- The largest and most varied molding facilities in the industry, with compression presses up to 2000 tons for regular and reinforced plastics in simple and complex shapes, injection presses up to 300 ounces, and large extruding and vacuum-forming machines.
- An experienced staff of research and development specialists, and a complete engineering department.
- Modern tool and die shops.
- A continuing advisory service, including a Customer Service Manager assigned to live with your job through every step of production.

These are some of the reasons why General American is the nation's leading custom molder of plastics. Let us study your products to help you determine whether the use of custom molded plastics will improve them. You'll find . . . *it pays to plan with General American.*

GENERAL AMERICAN TRANSPORTATION CORPORATION

135 South LaSalle Street, Chicago 3, Illinois
Offices in principal cities

Plastics Division

For more information, turn to Reader Service card, circle No. 469

For more information, circle No. 521 ➤

d'ARAZIEN

Alcoa puts the metal where you want it

More than a hundred tons of Douglas DC-8 kiss the runway on forged aluminum wheels like this one. Strength and lightness are obvious requirements. Even more essential is reliability through landing and after landing to guard the safety of passengers and crew.

Logically enough, rugged aluminum forgings were elected for the job. Then came many hours of Alcoa skill in die design, demonstrated in the remarkable zebra stripes visible in the cross section. They represent the aluminum grain flow* and illustrate how the tough aluminum grain is forged to withstand the shock loads of landing impact, plus the cyclic fatigue of rotation, all with a wide margin of safety.

Alcoa forges these wheels with a unique combination of blocker and finishing dies to put the metal exactly where it's needed. Alcoa Alloy 2014-T6 assures excellent machinability for the designer and producer, Bendix Products Division, Bendix Aviation Corporation. And Alcoa's forging plants, with hydraulic press capacities up to 50,000 tons, provide on-the-nose deliveries.

Think of Alcoa® Forgings when strength and lightness are rigid design requirements. Producing a complete line of forgings, Alcoa forges more large and complex shapes than any other supplier. Aluminum Company of America, 919 Alcoa Building, Pittsburgh 19, Pennsylvania.

**The patterns shown in the illustration were produced in Alcoa's Research Laboratories as part of a study of grain flow developed by the dies used to forge the DC-8 wheel.*

Alcoa puts the metal where you want it—in castings, forgings, impacts, extrusions and screw machine parts.

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

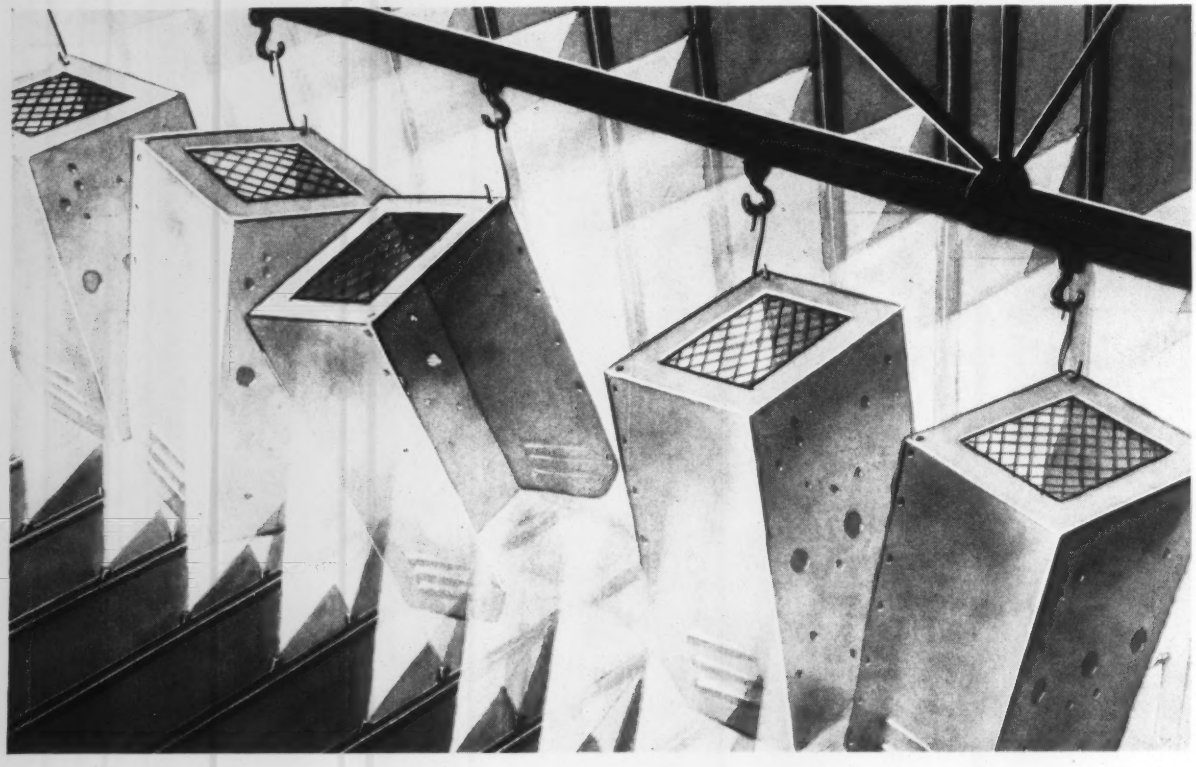
For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

Your Guide to the Best in Aluminum Value

For tough steel cleaning jobs

ask Oakite

OVER 50 YEARS CLEANING EXPERIENCE • OVER 250 FIELD SERVICE MEN • OVER 160 MATERIALS



New acid cleaner Oakite 86 gives fast smut removal . . . good paint grip

Shop smuts on steel parts disappear fast with Oakite 86 in the washing machine. A superior acid detergent, it removes all kinds of soils efficiently—really goes to work on heavily smutted steel. In addition, it forms a conversion coating on steel surfaces to give a good grip on subsequent paint coats . . . helps inhibit corrosion.

Oakite 86 also works well when aluminum, zinc, brass and terneplate pass through the washer.

And it is just the latest in a complete line of Oakite materials for spray washing machines. Others include products for high-pressure spraying, for rapid cleaning, for heavy-duty cleaning, for low-heat cleaning, for conversion coatings. Ask the Oakite man which one will work best with your machines, your metals, your specific jobs. Or, write for FREE bulletin. Oakite Products, Inc., 32H Rector Street, New York 6, N. Y.

it PAYS to ask Oakite

OAKITE

50 1909-1959 SCIENCE

years' leadership in industrial cleaning

For more information, turn to Reader Service card, circle No. 372

No draft
No machining

BETHLEHEM FORGES THIS
HIGH-PRESSURE STEAM TRAP WITH NO DRAFT

There's not an ounce of useless metal to pay for—or machine away. Our customer saves a good many metal and machining dollars. Chances are, Bethlehem's unique ability to forge with one degree drafts *or less* can help you save, too. It's easy enough to find out. Just call or write our nearest sales office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 431

High voltage "lightning" discharge at a Malleable test block.

Toughness is Malleable

Under the slamming, bruising strain of a bulldozer's roughshod ride . . . inside the battering air hammer . . . against the repetitive concussion of a machine gun's smashing action . . . wherever conditions are really brutal, Malleable iron castings prove their ruggedness.

When you're looking for toughness, it will pay you to investigate Malleable castings. Contact one of the progressive firms that displays this symbol—

If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

MEMBER
MALLEABLE
CASTINGS COUNCIL

(Advertisement)

New Malleable Irons Meet Gruelling Service Tests

Toughness is a vital requirement in stressed parts. Each application, however, requires a particular combination of physical characteristics to be sufficiently "tough."

Whatever the specific requirements, one of the finest groups of materials available is the Malleable irons, as illustrated in the tables below.

Tensile Properties—A.S.T.M. Minimum Specifications
Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p.s.i.	Yield Strength p.s.i.	Elongation % in 2 in.	Designation	Tensile Strength p.s.i.	Yield Strength p.s.i.	Elongation % in 2 in.
Standard				53004	80,000	53,000	4
35018	53,000	35,000	18	60003	80,000	60,000	3
32510	50,000	32,500	10	80002	100,000	80,000	2
Pearlitic							
45010	65,000	45,000	10				
45007	68,000	45,000	7				
48004	70,000	48,000	4				
50007	75,000	50,000	7				

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

Other Mechanical Properties
Standard and Pearlitic Malleable Irons

	Standard	*Pearlitic*
Modulus of Elasticity in Tension, p.s.i.	25,000,000	26,000,000—28,000,000
Ratio of Fatigue Strength to Tensile Strength	0.54	0.40—0.50
Shear Strength—% of Tensile Strength	80—90%	70—85%
Torsional Strength	Approximately equal to Tensile Strength	
Compressive Strength, p.s.i.	200,000	250,000

Malleable's toughness is illustrated in a severe test conducted by a manufacturer of cab-over-engine trucks. To be absolutely sure of the strength and toughness of a variety of components in the cab, including the critical Malleable iron cab support hinges, a truck was crashed at high speed into a barricade of ice. Result—no hinge damage, even though the truck was seriously battered.

Service-Demonstrated Toughness

Highway railing posts demonstrate Malleable castings' use where impact resistance is critical. As an example, thousands of Malleable railing posts line the Connecticut State Thruway. The State Highway Department reports that there have been no failures of the Malleable iron posts although other materials have failed in several cases.

It is also because of Malleable's toughness that so many of the highest quality hand tools are made of Malleable iron. One leading tool manufacturer tests the quality of its pipe wrenches by using a trick well known as the best way to break a wrench. The wrench jaws are put on a rigid bar, a long pipe is slipped on the handle, and the tester heaves his weight downward on the pipe. Because of their confidence in Malleable's toughness, this company unconditionally guarantees every Malleable wrench housing against distortion and breakage. Another hardware manufacturer makes a similar guarantee against breakage on its line of Malleable vises.

But Malleable iron's proven performance in field service is only one reason for its wide use. To this, you must add Malleable's low first cost, design flexibility, and excellent machinability. This combination offers unique advantages over other metals.

Design and Production Assistance Available

To assist in the use of Malleable castings, a special bulletin on toughness—Data Unit No. 105—is available from the Malleable Castings Council, Union Commerce Building, Cleveland 14, O. These bulletins and engineering and planning assistance are also readily available to you from any member of the Malleable Castings Council.

These companies are members of the

MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
National Mall. & Steel Castings Co., Indianapolis 22
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

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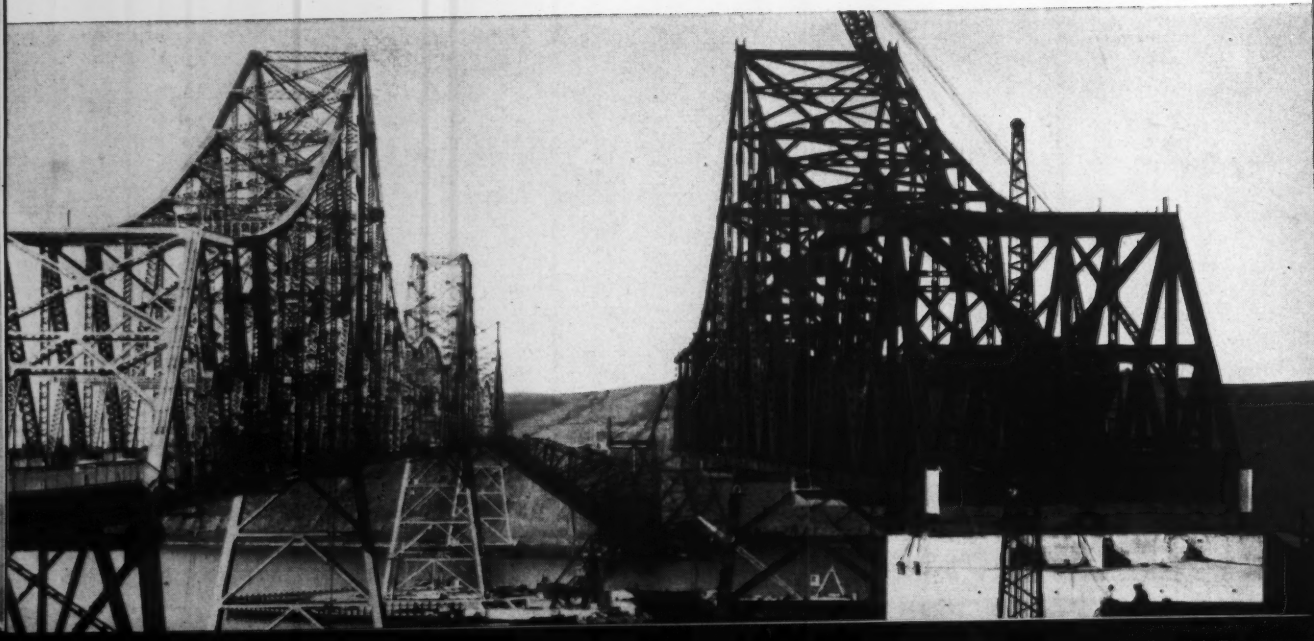
Jointly, We've come a long way since man first found that he could unite pieces of metal by

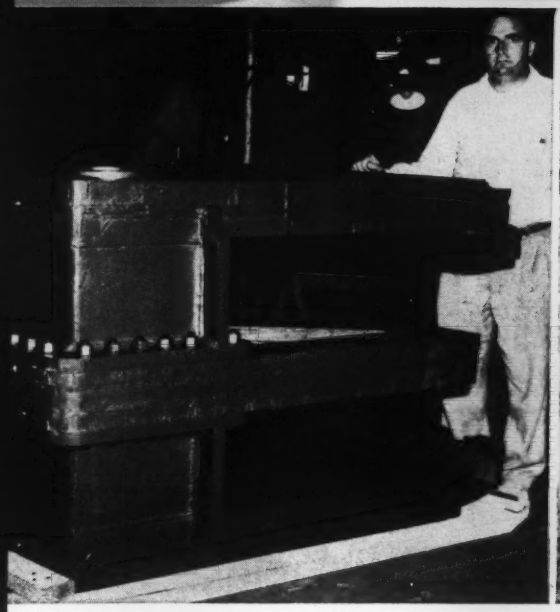
No matter what technique you use, the finished joint is best when the welded material is steel.

STEELS FOR DESIGN

beating them together while they were hot. Now there are almost 40 different welding techniques.

Above, you see a close-up photograph of arc-welding. For a more complete picture of welding, turn the page. ▷ ▷ ▷





Stainless Steel makes a flawless milk can—Milk cans have to be surgically clean. That's why the John Wood Company makes them from Stainless Steel, with **welded** joints. Here, you see a "Heli-arc" welding machine that was specially designed to weld the inside bottom and outside bottom of the can in one operation. The welding head is retracted to the breast of the can where again, the inside and outside welds are done in one operation. A nipple is gas-welded to the bottom of the can and all the joints are polished to a mirror finish—ready to pass microscopic inspection. Because of the outstanding design and fabrication processes developed by this company, they are now equipped to produce 50% of all the Stainless Steel can requirements for the entire dairy and vending machine industries.

USS "T-1" Steel stops saddle block failure—A saddle block links the dipper stick to the boom of a power shovel (see arrow above) and provides the digging effort. It has to withstand tremendous stress and shock—failures are not uncommon. But one operator had too many saddle block replacements so he asked J. B. Lund's Sons Co. to make a stronger unit. The conventional solid cast steel or forged steel block would have been too vulnerable, so the additional strength had to come from a **welded** assembly of strong steel plates. But the higher carbon content that increases the strength of most types of steel also decreases the weldability. They solved the dilemma with USS "T-1" Constructional Alloy Steel. "T-1" brand is a **low** carbon, quenched and tempered alloy steel with tremendous strength—100,000 psi minimum yield strength. The photo shows the finished block made from "T-1" steel plates that were edge-welded 1¼" deep. This block has never failed.

High Strength Steel cuts dead weight—You can stand beside the Carquinez Strait in California and size-up thirty years advancement in bridge building. There are two spans there, side-by-side; one is 31 years old, the other was completed last year. The builders of the new span saved 2,128 tons of steel because they designed the new Carquinez Strait Bridge with USS TRI-TEN High-Strength Low-Alloy Steel and USS "T-1" Constructional Alloy Steel. With yield strength levels of 46,000 psi min. and 90,000* psi min., respectively, these ultra-strong steels permitted thinner, lighter truss members that were shop-welded instead of riveted. 100% efficiency butt welds saved 20% in the weight of tension members by providing extra material at the holes for the connection bolts. The smooth, rivet-free surfaces are less vulnerable to corrosion . . . save thousands of dollars in maintenance.

USS, "T-1" and TRI-TEN are registered trademarks

*Now 100,000 psi for plates up to 2½ inches.

STEELS FOR DESIGN

United States Steel USS

ORCO

"Customeered" components basic to industry

ideas on "Customeered" RUBBER PARTS

...their design and application for improved product performance **No. 2**

8-ft. rubber-metal "sandwich" resists chewing by weather, oil and millions of vehicles

Bonded-rubber component assures higher accuracy, longer operating life of vehicle detector contact unit

Pressure-sensitive detectors installed flush with roadway surfaces are vital factors in today's ever expanding vehicular world—are used for traffic control, toll collection, automatic door opening, etc.

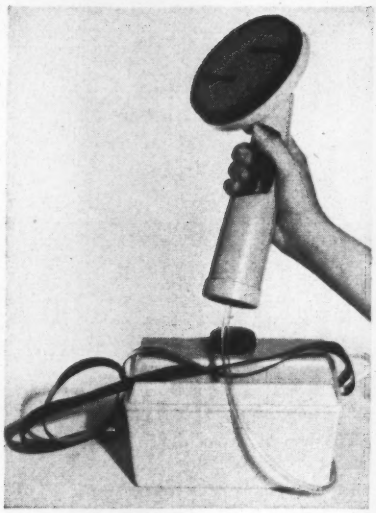
A contact unit produced from molded-rubber bonded to heavy-gauge and thin-gauge metal strips serves as an actuator in the detectors. The pressure of a vehicle passing over the contact unit mounted on a steel frame below the surface of the road puts the detector to work—initiates a count or any specific action the detector is designed to perform.

The requirements for the sandwich-like bonded-rubber component comprising the contact unit: A completely waterproof and airtight air space within the full length of the one-foot wide units produced in varying lengths of four, six, eight and ten feet; resistance to the harmful effects of constant exposure to weather, sunlight, salt, oil and tire chains; an operating life involving a minimum of many millions of crossings by all types of vehicles.

The resulting design involved an exceptionally difficult molding and bonding job. Included were combinations of hard and soft rubbers. Careful attention had to be paid to many important and minute details of production and intricate design not only to meet the customer's stringent requirements for longer operating life but also to make good on rigid PSI specifications.

Ohio Rubber's wide and varied experience in "customeering"* to unusual specifications, as well as its broad, up-to-the-minute manufacturing facilities, were both equal to the challenge—successfully met all the requirements. The bonded, molded-rubber contact units are in regular production at Ohio Rubber.

PHOTO COURTESY AUTOMATIC SIGNAL DIVISION, EASTERN INDUSTRIES, INC.



MOLDED-RUBBER TUBE STORES AND PUMPS CLEANING FLUIDS

A most important part in the new Swirl-away Cleaner for walls, upholstery, woodwork, etc. is a molded-rubber tube which serves both as a secondary storage tank and vacuum pump for cleaning fluid. Unusual in shape and requirements the tube involved a complicated mold, close tolerances, and a control rate stock with particularly high resistance to harsh chemicals normally found in detergents. Problems on the design and production of this intricate rubber component were successfully worked out by engineers at Ohio Rubber where the part is now produced.

RUBBER-METAL PUMP IS KEY TO NEW DISHWASHER FEATURE

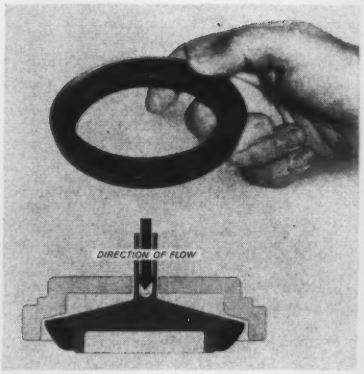
A vital component in a dual action pump which makes possible a "flush-away drain" feature in the dishwashers of a leading manufacturer, is a rubber-metal housing. Since rubber was required at several points for sealing and vibration absorption, the manufacturer asked Ohio Rubber engineers for help in designing and producing a pump housing of molded rubber bonded to a carbon-steel frame or insert. The material in the housing, which is in regular production at Ohio Rubber, also fully protects the frame from corrosive effects of both water and detergents.

THERE ARE MANY MORE EXAMPLES

of how Ohio Rubber "Customeered"* components are helping to improve product performance for outstanding original equipment manufacturers in every industry. For more information on Ohio Rubber "Customeering"*—molding, extruding, bonding-to-metal—with rubber, synthetic rubber, silicone rubber, polyurethane and flexible vinyl, write today to The Ohio Rubber Company, Willoughby, Ohio. 9DE2

**Trademarks of The Ohio Rubber Company*

Sewer-Pipe Seal – Precision extrusion of high specification rubber by ORCO provides an effective new approach for obtaining sealed or "premium joints" in sewage disposal lines—prevents surface water infiltration to reduce treatment costs. Available in a wide range of popular sizes, plus close tolerances, for concrete as well as clay pipe.



Orthane Valve Seat – Durable as the hardest steel yet resilient enough for sealing, this valve seat of molded polyurethane by ORCO is used in specialized oil field operations where it must successfully withstand the highly abrasive impact of raw crude oil mixed with gravel at pressures which often go as high as 20,000 PSI.

THE OHIO RUBBER COMPANY

Willoughby, Ohio

ORCO

A DIVISION OF THE EAGLE PICHER COMPANY

EAGLE EP PICHER

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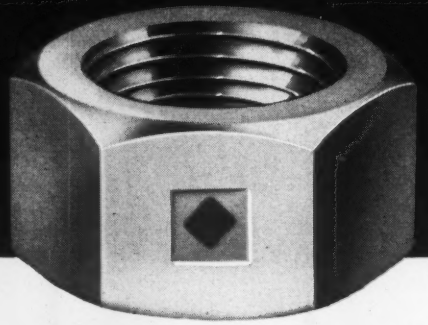
REPUBLIC NYLOK® FASTENERS



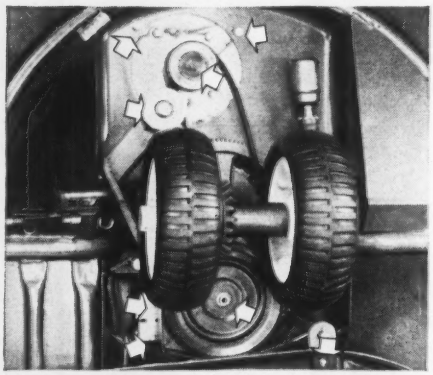
Users from coast to coast know about the quality construction of Roberton Twin Power Riding Mowers, made by Roberton Manufacturing Company, Chicago, Illinois.

Efficient riding mowers like these, constantly used to cut grasses of varying thickness and height, are subject to intense vibration. Yet their *two* power units are firmly held in place for long, dependable service by a total of 44 Republic Nylok Fasteners.

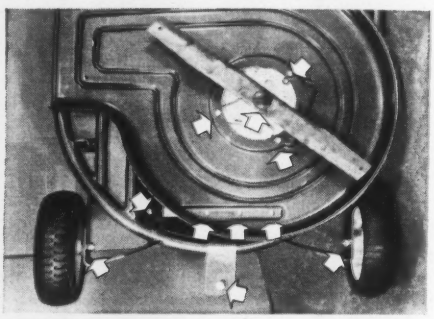
Republic Nylok Fasteners have a special nylon insert that assures positive locking at any position, even under severe shock, vibration, or tension. When the fastener is assembled, this nylon plug exerts pressure in a lateral direction, preventing all play, and utilizing the metal-to-metal contact of the opposing threads for locking.

Republic Nylok Fasteners provide maximum holding power under all conditions, whether seated or not; and they can be used repeatedly. One of their unique advantages is the "plastic memory" of the nylon plug—the tendency of the nylon to recover its original shape after assembly. This "growth" into the threads actually results in a tighter locking action, after a period of time, than when the fastener was first assembled.

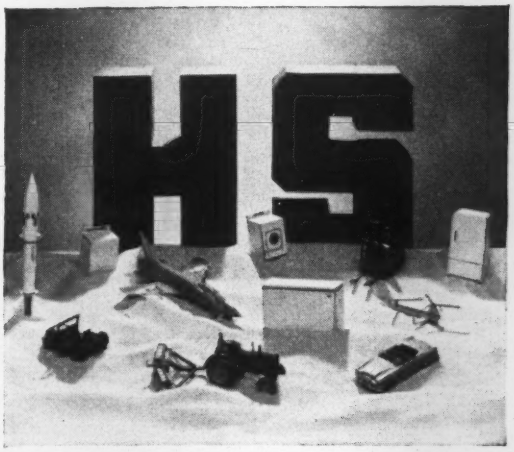
The nylon insert is unaffected by age or cold, has high resistance to heat, and very low moisture-absorption rate. These are but a few of the reasons why Roberton Manufacturing Company uses Republic Nylok Fasteners in its advanced line of power mowers. Advantages like these can pay dividends in *your* application, too. For full information, contact your Republic representative, or mail coupon.



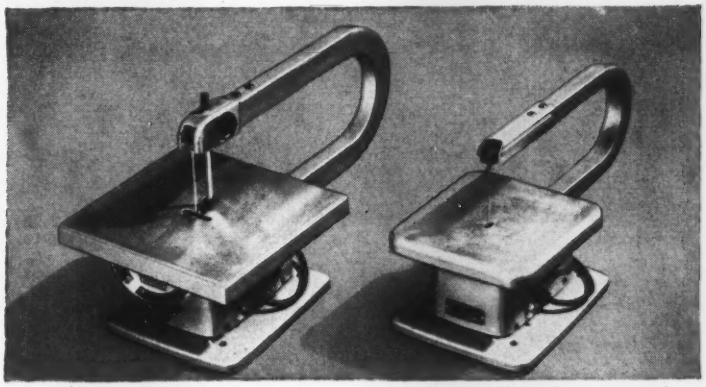
DRIVE UNIT, which furnishes motive power for Roberton Mower is securely held in place by Republic Nylok Fasteners as indicated by arrows. Engine remains tight against base even after years of hard service.



POWER FOR CUTTING is provided by a second, independent engine. Imagine the vibration set up by the swift-moving blade shown. Yet Republic Nylok Fasteners hold engine, wheels, and other parts, firmly in place.



REPUBLIC'S NEW HIGH STRENGTH POWDER, Type HS6460, opens the way to new markets for new applications using sinterings for highly stressed parts. Type HS6460 can be used with existing operating equipment. It provides a minimum tensile strength of 60,000 psi at 6.4 density as sintered, and 100,000 psi heat treated. Type HS6460 maintains its dimensional characteristics after sintering—less than .004 inches per inch shrinkage from die size at 6.4 density. Available in production quantities up to and including 12 tons, or in multiples thereof. Mail coupon for technical data sheet on Type HS6460 Powder.



EASY, EFFECTIVE FABRICATION is a characteristic of Republic Galvannealed Steel Sheets. Severe brake forming, shown above as done by Fogel Refrigerator Company, Philadelphia, does not affect their corrosion-resistant, paint-adhering qualities. Republic Galvannealed Sheets readily take shearing, punching, spot welding, and many other fabricating operations. Mail coupon for more facts.

SAVINGS IN A KEY PART are realized by Syncro Corporation, Oxford, Michigan, by using Republic ELECTRUNITE® Mechanical Tubing in the manufacture of jigsaws. Previously they used a casting for the blade-yoke, which requires a severe bend. ELECTRUNITE Square Tubing was recommended for one model, rectangular tubing for the other. Results: reduction in weight of the blade-yoke, and improvement in appearance of the product, with savings in time, materials, assembly, and shipping costs. For more information mail coupon below.

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☐ Type HS6460 Powder
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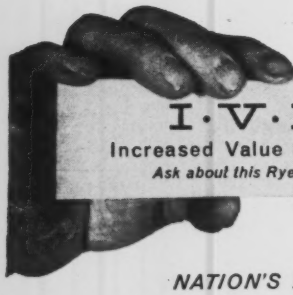
but only one was right for the job

Severe stresses imposed by this forming operation caused a high rate of reject for a fabricator using hot rolled plate to the usual ASTM—A7 specification. A call to his Ryerson Steel Specialist brought a suggested change to Ryerson welding and forming plate—a prompt solution to a costly problem.

Even in "plain carbon steel" applications, there's usually only one steel that's *exactly right* for each job. Nationwide, daily experience with a wide range of material selection and fabricating problems puts your Ryerson Specialist in the best position to know what is exactly right for *your* job. Backed by complete and diversified stocks, Ryerson can best supply that exact specification fast!

Let us help you make sure you get optimum value for your steel-buying dollars on every order—call Ryerson today.



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Liquid-insulated transformers *are one of the major uses of liquid dielectrics. The 37.5-kva distribution transformer shown is being impulse tested.*

For safety or improved operation . . .

Synthetic Fluid Dielectrics

Askarels
Fluorocarbons
Silicones
Diesters

One or more of the fluids in these four groups of liquid dielectrics can provide substantial benefits in transformers, capacitors, switches, cables and circuit breakers.

by Frank M. Clark, *Consulting Engineer, General Electric Co.*

■ Among the more important limitations of mineral petroleum oil—still the most widely used liquid dielectric—are 1) difficult-to-control chemical composition, 2) susceptibility to oxidation, which may result in dielectric degradation, increase in corrosivity, and formation of sludge, and 3) flammability.

Synthetic liquid dielectrics are higher in cost than mineral oil. But one or more of them can offer substantial benefits where certain of oil's limitations must be overcome, or where additional benefits, such as improved heat dissipation, improved high frequency operation, or an increase in permissible service temperatures, are desired.

Each of the four groups of synthetic fluids discussed here is large. Characteristics of specific liquid dielectrics vary widely, even within each generic group. Consequently, the discussion here is not intended to be comprehensive. Its purpose is to generally characterize the four groups, i.e., to help in initial screening as the first step in the ultimate selection of the proper type.

Askarels

are noninflammable, easily controlled in chemical composition, chemically stable, and not subject to oxidation. They are used primarily in electric capacitors and transformers.

"Askarel" is a generic term applied in this country to synthetic noninflammable insulating liquids

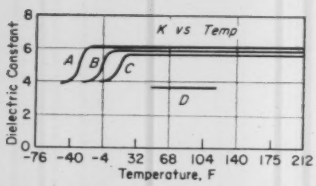


***Fig 1**—Effect of temperature on dielectric constant of capacitor paper impregnated with three askarels (A—trichlor diphenyl, B—tetrachlor diphenyl, and C—pentachlor diphenyl) and mineral oil (D).*

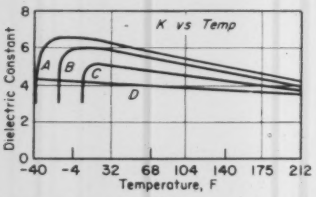


***Fig 2**—Blend of chlor diphenyl and chlor benzene (D) shows improved dielectric constant at low temperatures, as compared with trichlor diphenyl (A), tetrachlor diphenyl (B), and pentachlor diphenyl (C).*

which when decomposed by an electric arc evolve only noninflammable gas mixtures (ASTM D901). Present commercial askarels are chlorinated derivatives of aromatic hydrocarbons, chlorinated to the extent that a chemical equivalent of chlorine and hydrogen is present in each molecule. Most widely used are chlorinated benzene and chlorinated diphenyls, such as trichlorbenzene and pentachlor diphenyl. (Actually the fluorinated liquids, discussed later, can also be classed as askarels.)

Care must be taken in selecting materials for use with askarels. Askarels have greater solvent action than mineral oil on many of the materials commonly used in construction of electrical equipment. Contamination of the liquid by solvent action often leads to degradation of dielectric loss characteristics; dielectric strength is rarely affected. Degradation of dielectric loss by contamination can be overcome in transformers by treating the fluid with activated alumina.

In general, the liquids attack most vegetable-oil-type varnishes. Mineral oil itself is soluble in askarels and the presence of oil may 1) affect their noninflammability, and 2) introduce a degree of explosivity in the gases formed during arcing. According to Underwriters' Laboratories, the amount of mineral oil in transformer askarel must not exceed 2% by volume.

Among materials suitable for use with askarels are completely cured synthetic resins, such as phenolics, urethanes, epoxies and cellulosics. Oil or asphalt modification of these resins frequently increases their susceptibility to attack by askarels.

Usual cellulosic insulations, such as kraft, cotton and linen papers, and cellulosic cord and pressed board, can also be used.

Properties

Typical properties of askarels are shown in Table 1, which gives average values for askarels composed of chlorinated diphenyl or mixtures of chlorinated diphenyl and chlorinated benzene.

For capacitors—The major benefit of askarels over mineral oils as capacitor impregnants is their higher dielectric constant (about 5 to 6 vs 2.2 for mineral oil). Higher dielectric constant permits a substantial decrease in size—about 50-60%—of an impregnated paper capacitor.

Fig 1 compares dielectric constant of typical commercial askarel-impregnated capacitor paper with that of a mineral oil-impregnated paper. As can be seen, dielectric constant of chlorinated diphenyl askarels decreases rapidly at the lower temperatures (temperatures of solidification). Where capacitors are to be used at temperatures below about −22 F, askarels composed of blends of chlorinated diphenyl and trichlorbenzene should be used (see Fig 2).

The high dielectric constant of askarels provides another advantage in capacitors. Because the dielectric constant of askarels more closely approaches that of capacitor paper (about 7), a more evenly distributed dielectric stress is obtained than with mineral oil.

For transformers—The major benefits of askarels as transformer insulators stems from their noninflammability. Two direct benefits accrue:

1. Economy in insulation — Safety codes call for installation of oil-filled high voltage transformers within enclosed, solidly built, fireproof vaults. Askarel-filled transformers of up to 15,000-v rating can, in many cases, be installed indoors, even on the factory floor, with only the usual protective guards to prevent contact with live parts of the transformer.

2. Ecomony in operation—Because of this freedom in selecting an installation site, askarel-insulated transformers can usually be

TABLE 1—TYPICAL PROPERTIES OF ASKARELS[a,b]

Use →	Capacitors		Transformers	
Spec Grav →	1.40—1.45	1.54—1.55	1.54—1.55	1.55—1.57
Fire Point, F	None	None	None	None
Pour Point, F	32 to 19	43 to 54	−40 to −58	−30 to −40
Viscosity (Saybolt Universal)				
99 F	200	3000	42	54
210 F	40	46	—	33
Coef of Ther Exp (77-150 F), per °F	38 x 10^{-5}	36 x 10^{-5}	37 x 10^{-5}	37 x 10^{-5}
Dielectric Strength (60-194 F)				
Kv/Cm	200	200	200	200
V/Mil	350	350	350	350
Dielectric Constant	5.3,[e] 4.4[e]	5.0,[c] 4.2[e]	4.5,[d] 3.9[f]	4.2,[d] 3.6[f]
Spec Res (194 F), ohm-cm	1-5 x 10^{12}	1-5 x 10^{12}	1-5 x 10^{12}	1-5 x 10^{12}
Power Factor (94 F)	0.015	0.015	0.01-0.05	0.01-0.05

[a]All are clear at 77 F with a yellow tint, have negligible free chloride ions, and an acid value of <0.01.
[b]Test methods are outlined in ASTM D901. [c]At 68 F. [d]At 77 F. [e]At 195 F. [f]At 212 F.

brought much closer to the point of power consumption. Studies have determined that every 1000 m (3250 ft) saved in the length of low voltage cable results in an added saving of about 0.4-0.5% in electric power transmitted.

A further economy in the operation of askarel-filled transformers results from the elimination of the problem of oxidation to which mineral oil is susceptible. With no oxidation, maintenance operations such as filtration of the liquid or complete periodic replacement of the fluid are eliminated.

Some problems— and how they're solved

Surge voltage breakdown—Power frequency voltage breakdown of askarels and askarel-treated insulation is equal to and in many cases superior to that of corresponding mineral oil insulation. However, in transformer construction when conditions are such as to cause a nonuniform distribution of voltage stress, surge voltage breakdown of the askarel insulation is lower than that of corresponding mineral oil insulations.

Solution of the problem lies in transformer design. Where it is possible for the electrical field to be uniformly applied, or when small insulation thicknesses are used, surge voltage breakdown of askarel insulations is equivalent to that of mineral oil insulations.

Arcing—During high voltage testing of askarel insulations, corona and minor arcing may occur. Arcing breaks down the askarel molecule, producing carbon and hydrogen chloride gas. Although hydrogen chloride is noninflammable, it may attack cellulosic insulation in the equipment. Such degradation can be eliminated by dissolving a "getter," such as tin tetra phenyl, in the askarel. The getter reacts with the hydrogen chloride preventing any possible reaction with insulating and structural parts of the transformer.

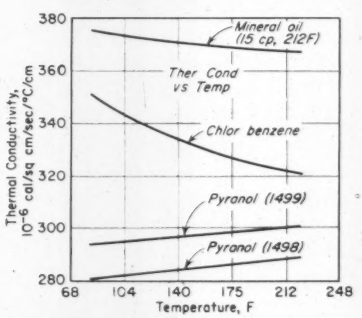


***Fig 3**—Thermal conductivity vs temperature for three askarels as compared with a typical petroleum oil.*

TABLE 2—TYPICAL PROPERTIES OF FLUORINATED LIQUIDS

Property ↓ Type →	$(C_2H_5)_3N$	$(C_3F_7)_3N$	$(C_4F_9)_3N$	$(C_4F_9)_2O$	$(C_6F_{13})_2O$	c-$C_6F_{12}O$[a]	c-$C_8F_{16}O$[a]
Pour Point, F	—	—	−58	—	−130	—	−148
Boil Point, F	156	264	352	214	342	133	217
Specific Gravity (77 F)	1.73	1.82	1.87	1.71	1.81	1.69	1.77
Viscosity (77 F), cs	0.50	0.80	2.74	0.61	2.11	0.47	0.81
Surface Tension (77 F), dynes/cm	—	—	16.1	13.0	16.3	—	15.2
Specific Heat, Btu/lb/°F	—	—	0.27	—	—	—	0.25
Heat of Vaporization, Btu/lb	—	—	29.7	—	—	—	37.6
Dielectric Constant (77 F)	1.89	1.85	1.86	1.77	1.85	1.85	1.85
Resistivity, ohm-cm	10^{16}	10^{16}	10^{15}	10^{16}	10^{16}	10^{16}	10^{15}
Dissipation Factor (77 F)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Dielec Str (77 F), kv	39	44	40	40	45	41	37

[a]Cyclic compounds whose exact structural formulas are not clear.

Low thermal conductivity—Fig 3 shows the thermal conductivity of askarels to be lower than that of mineral oil. This difference can be important where insulating liquids act also as coolants. In transformer cooling, where convection is more important than conductance, the lower conductivity of askarels may be of minor importance. However, under certain short overload conditions low conductivity may be of major importance.

In capacitor applications, the lower thermal conductivity values are of greater importance.

Fluorocarbons

are noninflammable, usable at high operating temperatures, extremely stable chemically, compatible with insulating and structural materials, and they have excellent cooling characteristics. They are used in transformers to permit reduction in size and increase permissible operating temperatures for special applications.

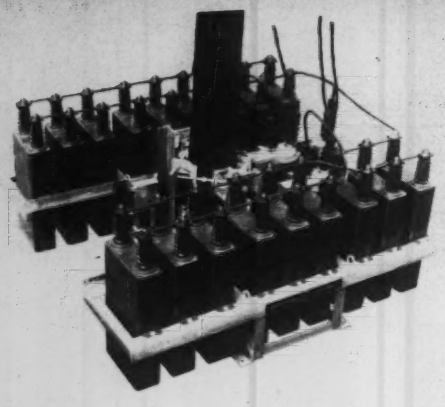
By definition, many fluorocarbon liquids can be classified as askarels. Here they are treated separately from the chlorinated aromatic hydrocarbons because of their distinct nature and their as yet limited use. Liquids discussed here include the fluoro and the chloro derivatives of aliphatic hydrocarbons and hydrocarbon derivatives. (Fluoro compounds normally gaseous or solid at room temperature, such as the Freons, or TFE fluorocarbon resins, are not included.)

Properties

Typical properties of the most important fluorinated liquids which have been considered for commercial use are shown in Table 2. In general, the liquids show low moisture absorption and a low order of chemical sensitivity to the presence of moisture. Dielectrically, the liquids have a low power factor (dielectric loss) over a wide range of frequency and temperature, and high dielectric strength. Dielectric constant is invariably low, near 2 or lower.

Use of the fluorinated liquids is subject to many of the same problems associated with the use of the askarels. If subjected to arcing, or otherwise decomposed, chemically corrosive products are formed. These products in some instances are toxic, and in all cases attack cellulosic insulations and some metals.

Effects of heat—Fig 4 and 5 show effects of temperatures as well as frequencies on dielectric characteristics of two typical



Capacitors *such as this twin-cluster pole-mounted switched unit make use of the higher dielectric constants of liquid dielectrics as opposed to petroleum liquids.*

fluorinated liquids. Use of such liquids boosts permissable transformer operating temperatures as high as 390 F. Of course, in such instances, cellulosic and other organic materials in the transformer must be replaced with 180 C (Class H) insulation.

The boiling points of fluorinated liquids are invariably lower than those of the askarels. In most transformer applications this lower vaporization point has been used to advantage in promoting more adequate cooling. Care must be taken to prevent the extremely corrosive vapors from contacting cellulosic insulations and some metals.

Effects of moisture—At 90% RH, solubility of water in fluorinated liquids is low—less than that of mineral oil or askarels. However, the effect of moisture on dielectric strength is greater than for mineral oil. For example, when various fluorinated liquids were exposed to air at 90% RH for 80 days, water content did not exceed 25 ppm, but dielectric strength of all liquids tested dropped to 15-17 kv.

Cooling characteristics — The excellent convective cooling characteristics of fluorinated liquids result from a combination of physical properties, such as low viscosity and high volume expansion, together with their greater ease of vaporization as compared with mineral oil.

The vaporization characteristics of fluorinated liquids substantially contribute to cooling characteristics. Low viscosity fluorinated liquids easily penetrate into the innermost portions of transformer windings. Here the liquid is vaporized on the development of a "hot spot," efficiently absorbing heat. The vaporized liquid is subsequently condensed in the cooler portions of the transformer. Studies indicate that heat of vaporization of fluorinated liquids may be as high as 37.6 Btu per lb. A nonvolatile transformer oil would absorb heat under the same conditions only in proportion to its specific heat (0.7-0.9 Btu per lb).

Another type of transformer application takes even greater advantage of the cooling efficiency accompanying vaporization of a liquid. A small pump forces the liquid from a sump to a nozzle through which the liquid is sprayed uniformly over the transformer coils. On hitting the warm coils, the fluorinated liquid—of a specified and controlled boiling point—is vaporized, thereby efficiently cooling the coil. The vaporized liquid is later condensed and returns to the collecting sump and the circulating system.

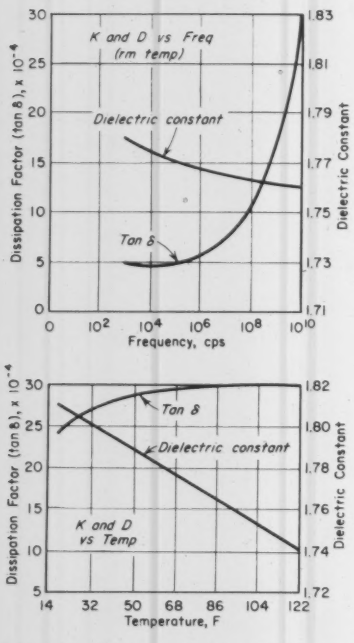


***Fig 4**—Effect of frequency and temperature on dissipation factor and dielectric constant of a typical fluorocarbon liquid (completely fluorinated heptane—C_7F_{16}).*

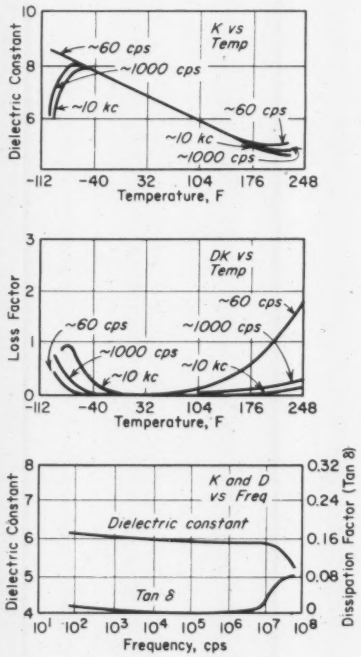


***Fig 5**—Effect of temperature and frequency on dielectric constant and loss characteristics of bisdodecafluoroheptylmethylgluterate.*

Silicones

are stable at high temperatures, have good viscosity-temperature coefficients, and are not subject to oxidation. They are used primarily for specialty high temperature transformers.

Silicone insulating liquids contain polymer units in which organic radicals or groupings and oxygen atoms are attached to each silicon atom. Most of the liquids discussed here are dimethyl silicones.

Properties

Typical physical properties of

selected silicone fluids are given in Table 3. At viscosities of 40 cs and higher the fluids are substantially nonvolatile. Lower viscosity fluids do possess a volatility which may be important in their use.

Silicone liquids have excellent viscosity-temperature characteristics, i.e., viscosity changes to a relatively small degree with change in temperature. Fig 6 compares this relationship for several silicone liquids with that of two petroleum oils.

In general, silicones show little or no solvent action on the usual organic lacquers, resin coatings and plastics. In some instances they cause a slight decrease in weight and volume of rubbers immersed in them for extended periods of time at elevated temperatures. They are noncorrosive to metals.

Thermal conductivity of silicones is strongly affected by viscosity, and may range from values lower than those of askarels to conductivity values about comparable with those of mineral oil at optimum viscosity.

Effects of heat and flame—Silicone fluids are generally stable to heat at temperatures up to 300 F, even in contact with air. They do not oxidize to form sludge. When heated at higher temperatures in air, an increase in the liquid viscosity occurs, with ultimate formation of a gel-like structure. Protected from air, silicones show marked stability up to 360 F. At somewhat higher temperatures (480 F), silicone polymers degrade by "cracking" into smaller molecular units.

Silicone liquids do not possess a conventional fire point value. Flame is extinguished upon removal of the heat source. If the liquids are maintained at sufficiently high temperature, vapors evolved will burn continuously with formation of silicon dioxide, carbon dioxide and water. Thus, silicone liquids present only a low order of fire or explosion hazard within the normally expected range of use, even at service temperatures up to 360 F.

Electrical properties—Dielectric strength of silicone fluids at 60 cycles ranges from 30 to 40 kv. Dielectric constant increases with increased viscosity from a value of 2.71 (40 cs) to 2.77 (100 cs or higher). Dielectric constant decreases linearly with increased temperature, as shown in Fig 7, but is little affected by frequency up to at least 1 mc. Insulation resistance is high, as can be seen in Fig 8 which shows resistivity as affected by temperature.

Power factor is characteristic-

TABLE 3—TYPICAL PHYSICAL PROPERTIES OF COMMERCIAL SILICONE FLUIDS[a]

Type ➡	SF96(40)	SF96(100)	SF96(500)	SF96(1000)
Viscosity (100 F)				
Kinematic, cs	40	100	500	1000
Saybolt Universal	189	460	2260	4620
Visc-Temp Coef[b]	0.588	0.590	0.599	0.599
Pour Point, F	−65	−64	−56	−56
Specific Gravity	0.964	0.965	0.969	0.969
Flash Point, F	599	608	608	613
Specific Heat, Btu/lb/°F	0.374	0.370	0.365	0.352
Coef of Ther Exp, per °F	0.00054	0.00054	0.00052	0.00051

[a]Four GE fluids of SF96 series. All are water white, clear, and have acid values of 0.04 mg KOH/gm.
[b]Viscosity-temperature coefficient = 1 − (visc at 210 F/visc at 100 F).

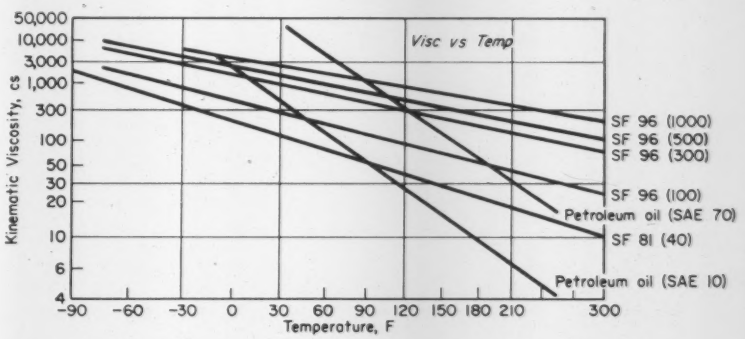
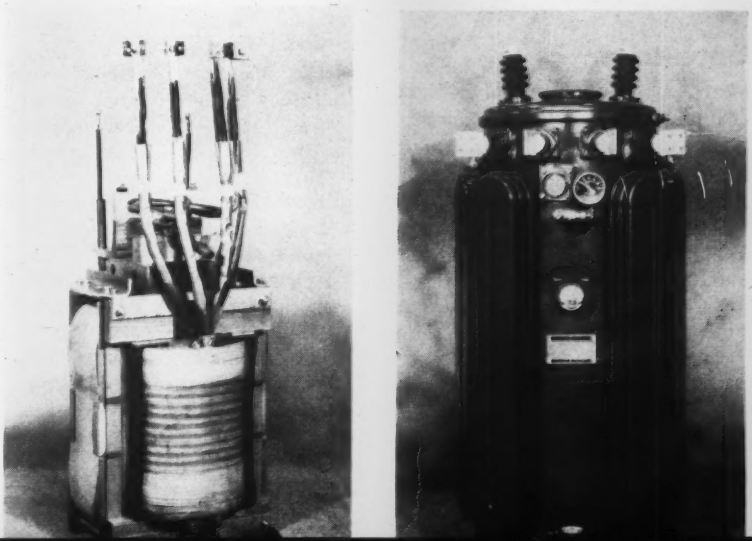


***Fig 6**—Viscosity-temperature curves for several selected silicone liquids compared with those for two typical petroleum oils.*

***Before and after** Interior core and coil of a substation transformer is shown at left prior to immersion in liquid dielectric; at right as completed transformer.*



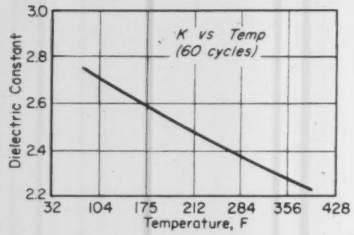


***Fig 7**—Effect of temperature on dielectric constant for a typical silicone liquid [GE SF96 (40)].*

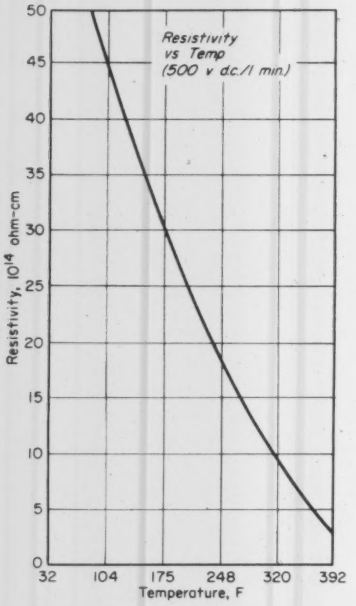


***Fig 8**—Effect of temperature on resistivity of a typical silicone liquid [GE SF96(40)].*

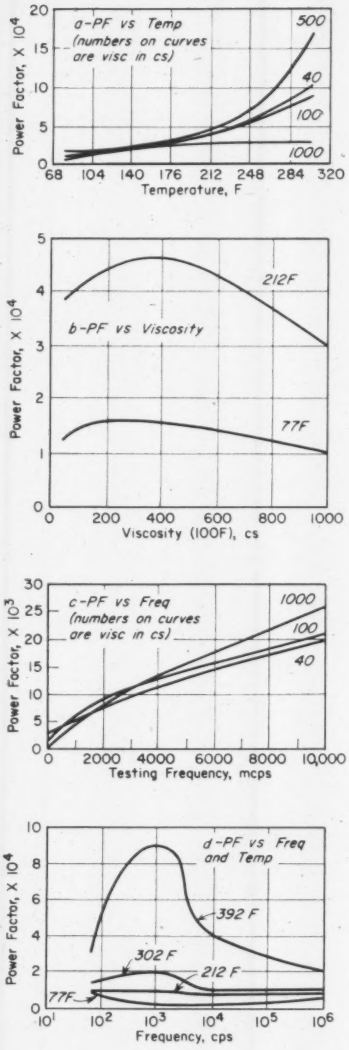


***Fig 9**—Power factor of typical silicone fluids as affected by: a—temperature, b—viscosity, c—frequency, and d—frequency and temperature.*

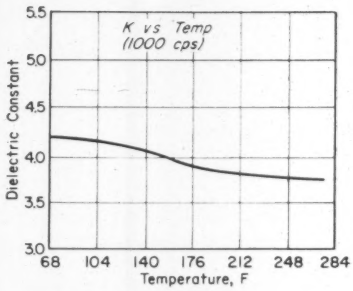


***Fig 10**—Dielectric constant of DBS versus temperature.*

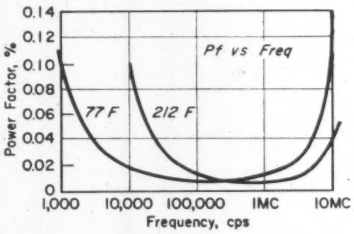


***Fig 11**—Effect of frequency on power factor of DBS at two temperatures.*

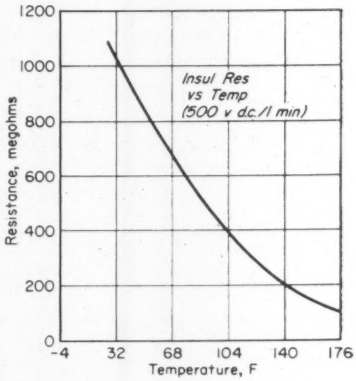


***Fig 12**—Effect of temperature on insulation of DBS.*

ally low. At 60 cycles and room temperature, power factor is invariably less than 0.02%. Curves in Fig 9 show effects of temperature, viscosity and frequency on power factor.

Organic esters

show extremely low loss at high frequencies. They are primarily used for sealed or semi-sealed high frequency apparatus, such as capacitors.

Although there are many organic esters, only a few have been successfully used as liquid dielectrics. In sealed or semi-sealed high frequency apparatus, low viscosity organic ester liquids are useful for their extremely low loss within narrow ranges of high frequency voltage. In using such liquids, the effect of temperature on dielectric loss at a selected frequency must be carefully evaluated. Also, protection against hydrolysis must be provided.

Properties

Properties of various organic ester insulating liquids are shown in Table 4. The properties of different organic esters vary widely, and their use as liquid dielectrics is limited to specialty applications. Most discussion here pertains to DBS (dibutyl sebacate), a typical organic ester now in commercial use in a GE high frequency, parallel-plate power capacitor.

The general properties of DBS insulating liquid are similar to those shown in Table 4 for butyl sebacate. The material is oxidizable and hydrolyzable. As with other organic esters, the liquid's sensitivity to oxidation and hy-

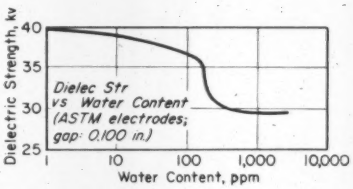


***Fig 13**—Effect of water content on dielectric strength of DBS.*

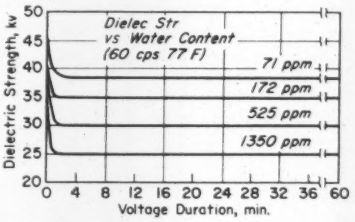


***Fig 14**—Effect of water content on time-voltage dielectric strength relation in DBS.*

drolysis must be controlled in all engineered applications.

Electrical properties—Dielectric constant of DBS, as shown in Fig 10, is high at 1000 cycles and is relatively unaffected by temperature. Dielectric strength is about 35-40 kv. Effects of both temperature and frequency on dielectric loss, as measured by power factor, are shown in Fig 11. The curve shows graphically the high loss characteristics of the liquid at low frequency, and the narrow frequency band in which DBS has extremely low loss characteristics. Fig 12 shows effect of temperature on insulation resistance.

Effects of moisture — Moisture dissolved in DBS causes the formation of acids. Formation is accelerated by elevated temperatures. As shown in Fig 13, dielectric strength is only slightly affected by moisture up to concentrations of about 100 ppm, beyond which further increase in amount of dissolved moisture has even less effect.

Room temperature dielectric strength, however, shows no tendency to fall below 30 kv, even at the point of moisture saturation (2000-2600 ppm). Under the same ASTM test conditions, dielectric strength of commercial mineral oil having a moisture content of 30 ppm is about 27-30 kv.

TABLE 4—PROPERTIES OF ORGANIC ESTER FLUIDS

Liquid	Pour Point, F	Flash Point, F	Visc (100 F), SSU[a]	Dielec Const (77 F, 60 cps)	Power Factor (77 F) x 10^3		Res (77 F), 10^{12} ohm-cm
					60 Cps	1000 Kc	
Amyl Oleate	10	347	47	2.9	2.3	0.30	—
Benzyl Benzoate	—	—	—	4.5	41.	0.30	1.0
Butyl Stearate	71	334	48	3.3	10.	0.13	5.0
Butyl Citrate	—	—	—	—	>500	0.10	<0.1
Butyl Ricinoleate	—	—	—	4.0	150.	3.1	—
Butyl Sebacate	14	347	46	4.4	10.	0.15	—
Butyl Oleate	18	354	49	2.9	8.	1.2	1.0
Butyl Lactate	−40	151	—	—	>500	1.0	<0.1
Butyl Carbonate	—	—	—	2.3	4.	0.15	<0.1
Butyl Laurate	16	284	39	3.0	26.	0.26	—
Butyl Borate	—	—	—	2.1	3.7	0.21	—
Butyl Naphthenate	—	—	—	3.1	16.0	1.3	1.0
Cyclo Lexyl Ricinoleate	—	—	—	—	60.0	1.9	—
Cyclo Hexyl Ricinoleate	—	—	—	4.3	>500	5.6	—
Di Ethyl Hexyl Adipate	−87	396	52	4.1	26.0	1.0	1.0
Ethyl Abietate	—	—	—	3.9	>500	—	—
Hexyl Ethyl Sebacate	—	—	67	3.8	20.7	0.7	—
Iso Amyl Benzoate	—	—	—	—	>500	0.8	—
Iso Propyl Benzoate	—	—	—	5.0	47.	0.05	—
Methyl Benzoate	—	—	—	—	>500	1.5	—
Methyl Stearate	79	313	44	2.9	>500	0.33	—
Methyl Ricinoleate	—	—	—	4.3	510.	1.7	—
Propyl Glycol Monolaurate	—	—	—	4.3	>500	5.6	—
Propylene Glycol Mono Oleate	—	—	—	4.2	>500	2.5	—
Tetra Hydro Furfuryl Oleate	0	399	61	4.3	19.	0.39	<0.1
Tetra Hydro Furfuryl Oxalate	−65	—	97	12.8	—	4.6	—

[a]Saybolt Universal.

Dielectric Liquids—Their Pros and Cons

Dielectric or insulating liquids are those liquids used either for a pure dielectric purpose, or as both insulation and heat transfer medium. Most frequently insulating liquids are used in conjunction with solid insulating materials, e.g., liquid impregnation or saturation of capacitor paper. (Such insulations should not be confused with those consisting of a solid material, such as paper, impregnated with a resin and subsequently cured to form a solid.)

Insulating liquids are used in equipment such as capacitors, cables, switches and circuit breakers to replace air or other gases and thereby obtain improved dielectric strength. They may also be used to improve both dielectric strength and heat dissipation characteristics of an assembly, e.g., liquid-filled transformers.

On the other hand, liquid dielectrics as a group have their drawbacks. Designers of electrical equipment are continually trying to achieve 1) lower cost, 2) smaller size, 3) wider temperature limits of operation, and 4) low weight.

In comparison with air, insulating liquids are expensive and heavy. These disadvantages may be offset by the smaller equipment made possible by the higher dielectric strength of liquids. Size reduction results in less material used per rated kva of electrical capacity of the machine.

When 60-cycle voltage is continuously applied to DBS containing moisture, there is a rapid drop in dielectric strength during the initial period. This drop becomes increasingly severe with increasing moisture content. However, as shown in Fig 14, continued application of voltage after the initial drop causes no substantial further change in dielectric strength.

This table shows

How Low Temperatures Affect Nine High Strength Alloys

by **R. L. McGee, J. E. Campbell, R. L. Carlson and G. K. Manning,** *Battelle Memorial Inst.*

Material	Nom Comp, %	Condition[d]	Temp, F	Yld Str (0.2% offset), 1000 psi	Ten Str, 1000 psi	Elong (2 in.), %	Red. of Area, %	Mod of Elast, 10^{-6} psi	Hardness (Vickers)[f]	Notched Ten Str, 1000 psi
STEELS										
17-7 PH[a]	C 0.08, Ni 7.0, Cr 17.0, Mo 0.3, Al 1.0	1400 F, 1½ hr; cooled below 60 F; 1050 F, 1½ hr (TH-1050)	79....	183	194	11	27	27.5	446	234
			−108....	195	216	12	22	28.9	466	237
			−320....	232	252	9.3	11	29.5	606	224
			−423....	256	263	0.6	3.7	31.0	690	158
AM-350[a]	C 0.07, Ni 4.25, Cr 17.0, Mo 3.0	1740 F, 1 hr, ac; −100 F, 2 hr; 850 F, 2 hr	79....	163	193	14	28	28.6	437	209
			−108....	189	216	17	25	29.3	479	232
			−320....	242	257	5.1	7.6	30.0	600	253
			−423	[e]	264	—	1.3	31.1	700	128
4340[b]	C 0.40, Ni 1.8, Cr 0.8, Mo 0.2	1575 F, 4 hr, oq; doubletemper 450 F, 4 hr each time	79....	225	269	12	40	28.4	531	344
			−108....	239	281	12	40	30.6	548	349
			−320....	279	319	10	24	30.6	639	270
			−423....	[e]	332	0.6	0.2	30.4	818	199
Tricent[b] **(Inco 300-M)**	C 0.40, Si 1.5, Ni 1.8, Cr 0.9, Mo 0.4	1600 F, 4 hr, oq; doubletemper 450 F, 4 hr each time	79....	239	283	12	42	28.2	551	387
			−108....	257	294	14	42	28.7	554	398
			−320....	299	336	4.3	5.0	29.9	622	255
			−423....	[e]	282	—	0.2	30.2	730	159
ALUMINUM AND MAGNESIUM ALLOYS										
7079[c]	Mg 3.0, Zn 4.7, Cu 0.5	T6	79....	60	72	12	21	10.0	160	101
			−108....	65	75	8.1	7.2	10.1	188	103
			−320....	74	83	3.1	2.9	11.3	211	105
			−423....	82	93	3.5	5.4	10.6	283	100
ZK60A[b]	Zn 5.4, Zr 0.5	T5	79....	38	46	26	3.5	5.9	73	61
			−108....	52	59	6.6	6.2	6.6	94	67
			−320....	54	67	2.1	4.8	7.3	97	71
			−423....	58	69	1.9	5.4	6.5	135	70
TITANIUM ALLOYS										
A110-AT[a]	Al 5.0, Sn 3.0	Annealed	79....	135	139	17	43	15.6	389	184
			−108....	163	170	10	21	16.2	428	214
			−320....	225	230	4.9	7.3	17.1	531	276
			−423....	264	270	3.0	9.0	17.0	605	232
C110M[a]	Mn 8.0	Annealed	79....	127	140	15	13	15.5	318	151
			−108....	169	176	13	19	16.6	388	191
			−320....	247	260	5.2	6.3	17.3	537	255
			−423....	[e]	201	—	—	17.6	625	150
6Al-4V[a]	Al 6.2, V 4.2	Annealed	79....	129	141	13	26	15.5	322	161
			−108....	156	167	11	29	15.9	383	193
			−320....	212	223	13	28	16.7	564	253
			−423....	260	267	1.9	2.7	19.4	744	234

[a]Sheet. [b]Bar. [c]Billet. [d]ac = air cooled; oq = oil quenched. [e]Fractured at less than 0.2% offset.
[f]10-kg load on standard Vickers indenter.

■ Considerable information on the properties of various metals at moderately low temperatures has been published previously. However, recent developments in the aircraft and missile fields require the use of materials at *extremely* low temperatures. The main reason is that liquid propellants can be retained only at temperatures of –297 F (bp of liquid oxygen or lower.

The materials listed above are important in airborne structures because of their excellent strength-weight ratios.

They were tested at four temperatures ranging from room to –423 F. As indicated, conventional tensile, notched tensile, hardness and impact tests were made.

General effects

In general, strength and stiffness of materials increase with falling temperatures. Ductility may or may not be affected. The change from ductile to brittle behavior may occur sharply or gradually, and is affected by both metallurgical and mechanical characteristics:

1. *Metallurgically,* structure is an important factor in the retention of ductility at low temperatures. In general, those metals and alloys having face centered cubic structures are ductile to very low temperatures, and their performance can be predicted. Metals and alloys having body centered cubic or hexagonal structures lose ductility more rapidly; in some alloys the transition from ductile to brittle behavior occurs at or above room temperature. In materials of this type, performance at low temperatures cannot be predicted and properties must be determined.

2. *Mechanically,* the effect of notches in highly stressed parts is well known; even surface scratches or tool marks can be points at which failure begins. These effects become increasingly important at low temperatures because of the reduced ductility of many materials.

Tensile properties

▸ In all of the materials, there is a general tendency for the tensile strength, yield strength and modulus of elasticity to increase as temperature is reduced. However, only 17-7 PH, the aluminum alloy, the magnesium alloy and two titanium alloys were sufficiently ductile at –423 F to develop the 0.2% offset necessary for the determination of yield strength. The other materials failed before reaching the required extension.

▸ Yield strength-density ratios, given in Fig 1, are substantially higher for the titanium alloys than for the steels, and aluminum and magnesium alloys at low temperatures.

▸ Notched tensile tests at room temperature show the strengthening effect to be expected of circumferential notches in bars; a comparable effect occurs in tests on sheet material. As temperature decreases, notched strength increases until a temperature is reached where ductility is relatively low. As temperature decreases further, notched strength decreases. At –423 F, all of the materials except the aluminum and magnesium alloys have notched strength lower than the unnotched tensile strength. These data show that notch sensitivity can be avoided only if the material retains some ductility.

▸ Ductility, as measured by elongation and reduction of area, tends to decrease with falling temperatures; in all of the materials elongation was greatly reduced at –423 F. However, at –320 F, 17-7 PH and 4340 steels retained 80% of their room temperature elongation and 6Al-4V 100% of its room temperature ductility. All of the other materials suffered drastic losses in ductility at –320 F.

Previous Articles

Everhart, John L., "How to Select Steels for Low Temperature Service," Jan '52, p 75.

Gela, T., Lepkowski, W. J. and Gade, H. M., "How Seven Nonferrous Metals Perform at Low Temperatures," Sept '56, p 116.

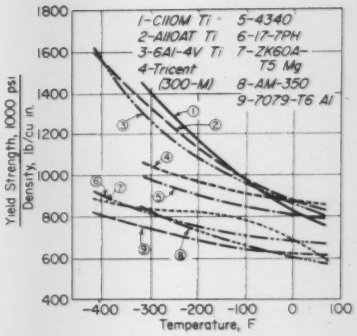


***Fig 1**—Yield strength-density ratios. Titanium alloys have substantially higher ratios than the other materials at low temperatures. However, violent ignition may occur when titanium is used in a liquid oxygen system under some conditions. Until more is known about this reaction, it is advisable to limit applications to non-oxidizing conditions.*

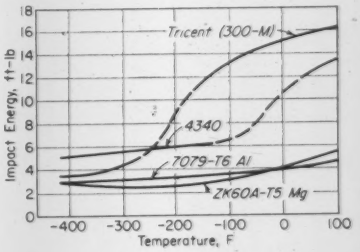


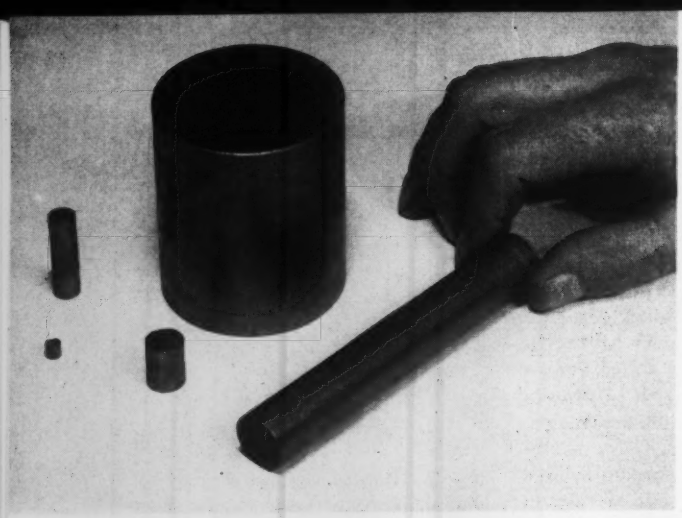
***Fig 2**—Effect of temperature on impact strength of bar materials.*

Hardness

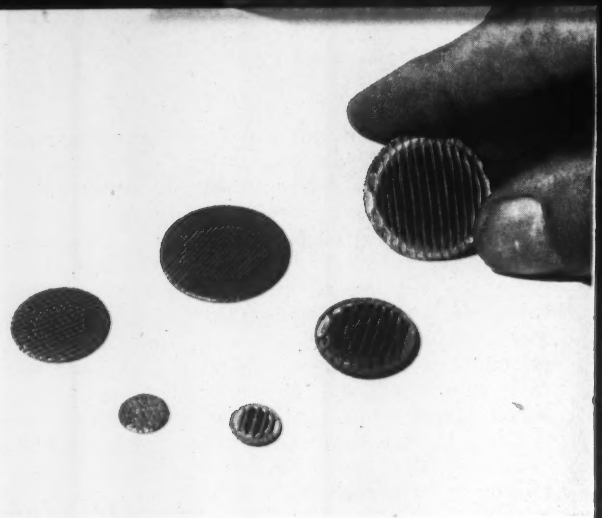
▸ Hardness of all of the materials increased with falling temperature. The hardness increased in proportion to the tensile strength up to the point where low temperature produced brittleness in the tensile specimens.

Impact strength

▸ As shown in Fig 2, the aluminum and magnesium alloys had relatively low impact strengths at room temperature but retained much of their ductility down to –423 F. The drop in impact strength of Tricent (300-M) and 4340 indicates that these alloys are subject to brittle failure under shock loading at temperatures below –320 F.



***Wire-wound sintered** filter elements (Poroloy) can be made in variety of shapes including cylinders. Depending on material, elements can be used up to 1500 F.*



***Pleated woven wire cloth** filters (right) are usable up to 1200 F. Flat disks are sintered wound wire filters.*

Selecting Materials for High Temperature Filters

Here are answers to some of the materials problems encountered in designing filters for use above 350 F.

by H. L. Wheeler, Jr., *Bendix Filter Div., Bendix Aviation Corp.*

Materials for housings and filter elements

Aluminum is suitable for filter housings at temperatures up to 350 F. However, because of its better strength-to-weight ratio at high temperatures, stainless steel usually provides a lighter and stronger housing at temperatures over 350 F. Housings operating at over 500 F must generally be made of high strength, corrosion resistant metals such as stainless steel, monel or titanium. Carbon steels are highly susceptible to corrosion at high temperatures and are not generally suitable for housings. However, low-chromium steel housings are sometimes used for filtering liquid metals.

High temperature filter elements can be made of metal powders, woven wire cloth (sintered or unsintered), and sintered wound wire (Poroloy). Both the metal powder and wire cloth elements have been previously described in this magazine (see box). The sintered, wound wire filter elements can be used to meet a variety of filtering needs at temperatures up to 1500 F, depending on the metal used. This type of filter element is available in many shapes and is easily fabricated.

High temperature filter elements can also be made in a variety of nonmetallic materials including porcelain, glass fiber, graphite and cermets. Porcelain is especially resistant to oxidation and is chemically inert. In general, porcelain, graphite and cermet filter elements have considerably less permeability than metal filter elements as a result of the very small size of the pores. Thus, the materials are well suited for specialized applications such as the cold sterilization of biologicals, for absorption of gases and vapors, and for polishing liquids. The materials are all inherently brittle.

Precipitation in stainless steels—Prolonged use of 300 series stainless steel filter housings and elements at 800 to 1500 F can cause carbide precipitation and a loss in ductility and corrosion resistance. Therefore, at 800 to 1500 F it is recommended that the 321 or 347 stabilized types of stainless steel be used.

Type 316 stainless has excellent resistance to oxidation and attack by halide acids and acid salts. Since it is only partially stabilized by the addition of molybdenum, type 316 is not as resistant to carbide formation as types 321 and 347. Because of its low carbon content, type 316L stainless has better resistance to carbide formation than 316.

Type 430 stainless is widely used in filter housings. Its corrosion resistance is only slightly less than that of the 300 series. However, it is subject to carbide formation above 1450 F.

Type 446 stainless has excellent

All-stainless filter *has welded end fittings, can be used to 1500 F.*

oxidation resistance in the range of 1300 to 1500 F but (along with type 430 to a lesser degree) is particularly subject to a phenomenon known as 885° brittleness. This precipitation phenomenon, which is not clearly understood, drastically reduces corrosion resistance and increases brittleness. All of the 400 types of stainless steel tend to be notch sensitive and have somewhat less strength than the 300 series at high temperatures.

Oxidation products—The formation of oxidation and corrosion products in filter elements lessens their usefulness and in some cases makes them completely ineffective. The 300 series of stainless steel, for example, forms loose blistery scales which clog element pores at temperatures above 1300 F. At temperatures up to 1500 F, type 446 stainless forms a harmless, tightly adherent scale but, as mentioned above, the material has other drawbacks. Inconel and HS 25 (a Haynes Stellite alloy) have good resistance to scale formation at high temperatures.

Corrosion problems — Many stainless and corrosion resistant steels are susceptible to attack by halogens, fatty acids, sulfur-bearing compounds and chlorinated hydrocarbons. Even the resistance of the 300 series stainless steels to nitric acid is reduced at high temperatures and pressures. Assemblies made with certain types of silver solder are particularly susceptible to attack by chlorides.

Manufacturers generally quote oxidation and corrosion data for relatively large blocks of material. When using such data for filter elements, keep in mind that the diameter of the wires in these elements is of the same order of magnitude as normal oxidation and corrosion layer thicknesses. Thus, the wire elements are more susceptible to failure by attack than a larger, more solid part such as a housing made from the same material.

Because of the many pores and crevices in filter elements, corrosion-producing chemicals may become trapped and cause damage even after the element is flushed. This damage is accelerated at high temperatures. Thus, it is not advisable to pickle or bright dip stainless steel filter elements in solutions containing hydrofluoric acid.

Seal materials

Seal materials present some of the most difficult problems in the design of high temperature filtration units. Rubber-asbestos, neoprene, styrene-butadiene rubbers (SBR), and other synthetics are seldom satisfactory over 300 F. Fluorocarbon seals may be used at temperatures around 500 F for limited periods, but they begin to decompose near 600 F. Viton A fluoro-elastomer seals have become popular for continuous temperatures of 500 F and for short time use at 600 F. Asbestos-metal seals are useful to much higher temperatures.

For more information on filter materials . . .

"Porous Metal Sheet," *Materials & Methods*, Apr '55, p 98.

"Where to Use Knitted Metal Parts," M/DE, July '57, p 112.

"Porous Metal Filter Media Solve Tough Operating Problems," M/DE, Jan '58, p 126.

"How to Select Woven Wire Cloth," M/DE, Mar '58, p 110.

A variety of metal seals can be used at temperatures above the useful range of plastics. Typical of available metals is stainless steel, which is popular for O-rings and K-rings.

In all designs the engineer should be sure that the seal material is compatible with the fluid used. Seals should be checked to see if they need replacement whenever the filter has to be cleaned, particularly after high temperature operation.

How temperature affects soldered and welded joints

Silver soldering is frequently used in high temperature filters to join end caps to the filter elements. The advantages of silver solder are ease of handling, minimum heat distortion and lack of scale and embrittlement. Silver soldered joints also have better fatigue resistance than welded joints. However, silver solder exhibits an abrupt decline in tensile properties above 800 F. Thus, welded joints must usually be used above this temperature.

Welding of filter housings and elements may produce unsatisfactory filter performance. Welding of unstabilized austenitic stainless steels such as 302 and 304 will produce considerable carbide precipitation in the weld zone. This precipitation can produce a serious drop in corrosion resistance and some loss of ductility around the weld. Such effects are less pronounced in types 316L and 304L stainless, and are virtually absent in fully stabilized types 321 and 347.

Welding of type 303 stainless should be avoided as welds in this material are very susceptible to cracking. In general, welds in the 400 series of stainless steels are neither as strong nor as ductile as welds in the 300 series.

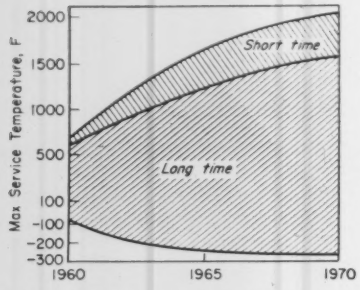
When welding end caps to filter elements, extreme care is required to minimize carbide precipitation and sigma formation, and resulting embrittlement and loss of corrosion resistance. These effects are amplified in small diameter wire used in high temperature filter elements.

Here are the materials requirements and expected improvements as forecast by the Aerospace Industries Assn. They are based on performance conditions established by a study of environmental and systems trends.

Engineering Materials: The Next Ten Years

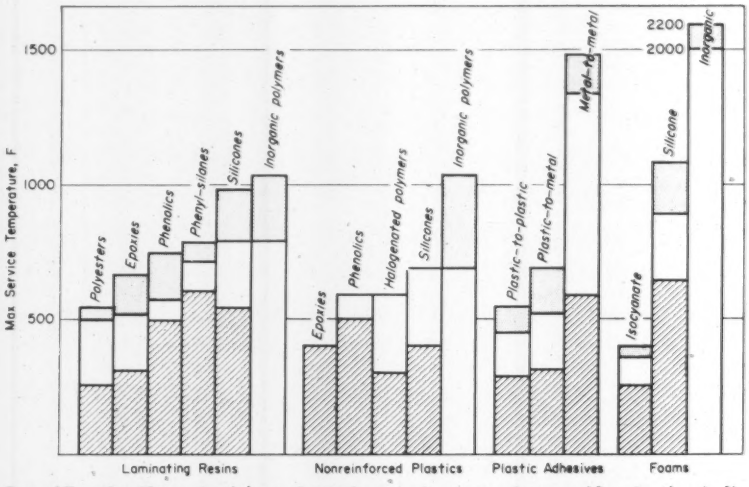
Source: *1959 Annual Forecast of Trends and Requirements, Part One, Aerospace Industries Assn.*

KEY: Present | 1960–1965 | 1965–1970



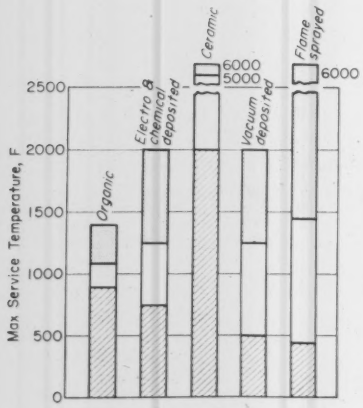
All plastics. *Anticipated requirements* for plastics materials fall into two categories of maximum service temperatures:

1. Short time service of about 0.1 hr.
2. Long time service of about 200 hr.



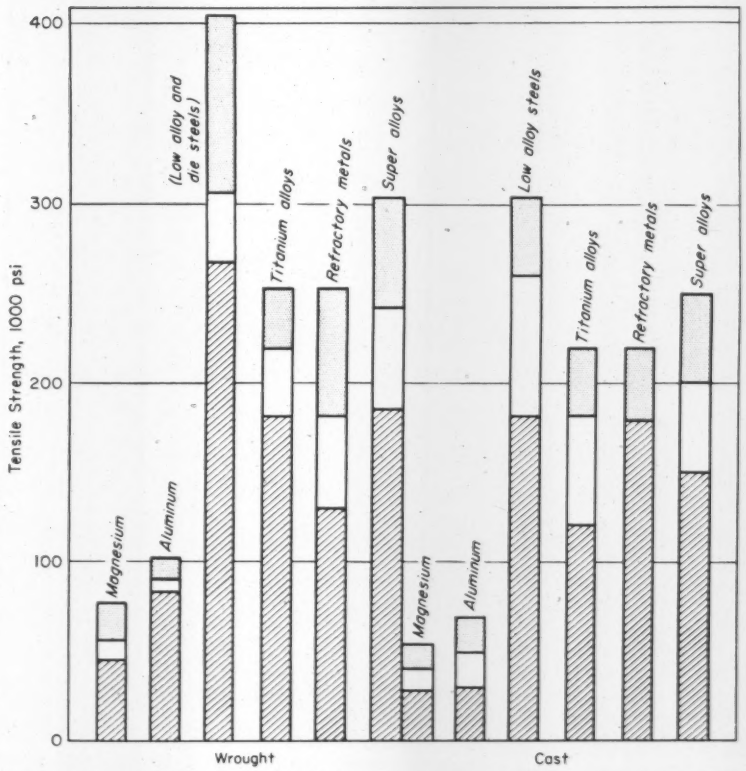
Specific plastics. *Anticipated 200-hr requirements* for specific plastics indicate that considerable advances are necessary. Some factors not included in this graph are:

1. Technology of laminating resins will require particular attention because it is presently behind reinforcing fiber technology.
2. Adhesives forecast includes organic, semi-organic and inorganic systems and assumes that minimum lap shear strengths of 1500 psi are maintained during exposure. The lower cost of structures fabricated by bonding instead of welding or brazing is expected to emphasize the indicated requirements.
3. Plastics foams also require advances in properties other than the temperature limitation, but this factor is primary at present.

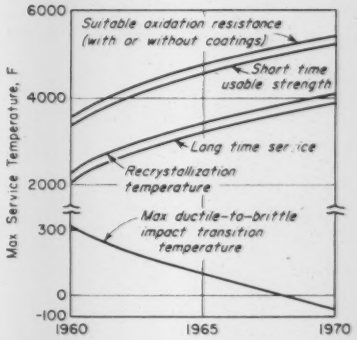


Coatings and finishes. *Anticipated requirements* will require great advances in finishing technology. However, except for organic finishes, coatings now in the experimental stage exceed the present requirements. Not included here are two important types:

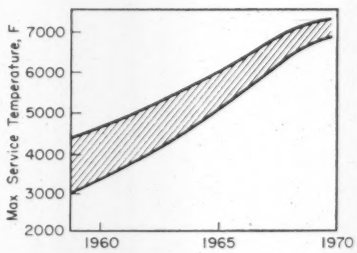
1. Multilayer electrodeposited coatings which offer infinite combinations.
2. Plasma jet coatings, now under development but requiring extensive work.



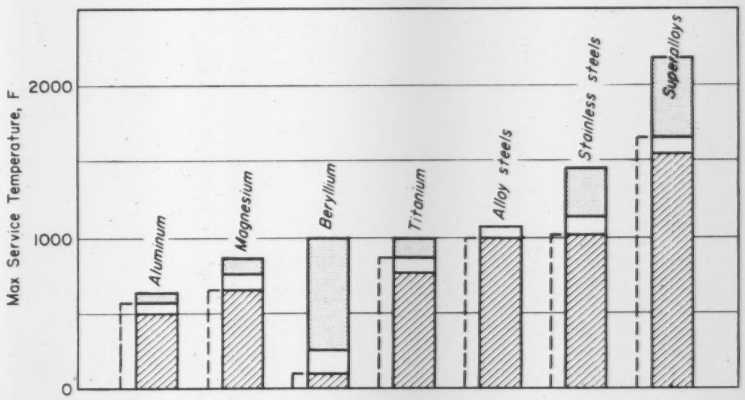
Wrought and cast metals. *Anticipated improvements* in the tensile strength of both wrought and cast metals show an approximately proportionate increase over present capabilities of both forms.



Refractory metal alloys. *These improvements can be realized* if proper emphasis is placed on the development and application of refractory metal alloys. The evaluation is based on columbium, molybdenum, tantalum, tungsten and their alloys. At present, alloys which have higher maximum temperatures also have higher minimum temperatures. The trend indicated here is that alloys should have both high service temperatures and a ductile-to-brittle transition temperature of —65 F or lower.



Ceramics and cermets. *Reasonable development* along the lines of increased service temperatures is indicated here. The forecast is based on ceramic materials intended for insulation and/or resistance to temperature.



Metals and alloys. Anticipated requirements, as well as present capabilities (broken line), are shown here. The requirements of higher service temperature often lead to denser metals. To avoid excessive weight, secondary requirements are:

1. Alloys that do not go through a brittle range below the maximum service temperature.
2. Improved fabrication characteristics, particularly higher ductility and better weldability.
3. Increased availability of close-tolerance mill forms.

American Brass Co.

Degreasing tank *is fabricated from high silicon bronze (A) by the inert-gas tungsten arc method using filler rod of the same composition.*

Silicon Bronzes

Use them where you need this combination { *Strength of mild steel* / *Corrosion resistance of copper*

by the Staff, *Materials in Design Engineering*

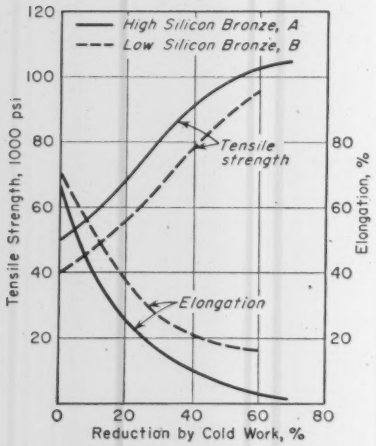


***Fig 1**—Effect of cold working on the mechanical properties of typical silicon bronzes.*

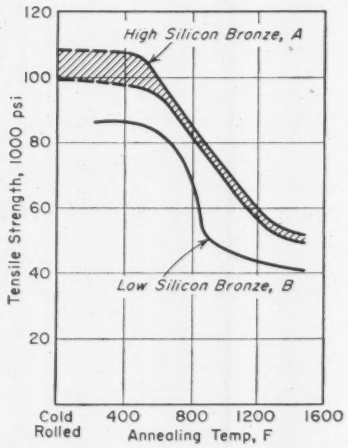


***Fig 2**—Effect of annealing on the mechanical properties of typical silicon bronzes.*

■ The silicon bronzes are a series of copper alloys containing from 0.8 to 3.6% silicon. In one modification, there is considerably more aluminum than silicon. Other elements such as manganese or zinc can be present in small quantities. Iron, nickel or tin are occasionally added in small amounts.

The outstanding attributes of the silicon bronzes are high strength and good corrosion resistance. Silicon bronze parts and equipment have been used for years under severe operating conditions, resisting exposure to all types of water, saline fogs, industrial atmospheres and a wide variety of corrosive liquors. They are used in chemical process equipment, marine equipment and hardware.

Classification

ASTM specifications cover the following classes:

1. *High silicon bronze (A)* contains 94.7% min copper and nominally 3% silicon. Limits of other elements are shown in Table 1.

2. *Low silicon bronze (B)* contains 96% min copper and nominally 1.5% silicon. Limits of other elements are shown in Table 1.

3. *Aluminum silicon bronze* contains 89% min copper, and nominally 2% silicon and 7% aluminum.

Examination of the compositions given in Table 1 will show that the specifications are given in broad ranges and this is intentional. Wrought alloys in commercial production are not often sold as silicon bronze. Each producer has his own specific composition which complies with the specification; these alloys are sold under trade names such as Duronze, Everdur, Herculoy and Olympic Bronze.

Properties

Nominal physical and mechanical properties of the silicon bronzes are given in Table 1. These properties are representative of the various grades and, of course, only approximate the properties that will be obtained on commercial alloys.

Physical properties—Silicon has a pronounced effect on the electrical and thermal conductivities of copper. The silicon bronzes have conductivities about 10% that of copper and are among the lowest conductors of the copper alloys. This resistivity is very useful in welding.

The densities of this group of alloys are rather low; aluminum silicon bronze is the lightest of the copper alloys with the exception of some of the aluminum bronzes.

Mechanical properties—Tensile strengths of annealed material range from 40,000 psi for alloy B to 90,000 psi for aluminum silicon bronze; yield strengths are in proportion. Ductility as measured by elongation is high for the aluminum-free types. Aluminum silicon bronze is considerably less ductile, a factor that makes this alloy unsuitable for cold fabrication.

Hardness ranges from Rockwell F60 to B90. Aluminum silicon bronze at Rockwell B90 is comparable in hardness with some of the carbon steels.

Effect of cold working on strength and ductility is shown in Fig 1. Low silicon bronze B does not develop as much strength upon working as high silicon bronze A, but retains greater ductility. For this reason alloy B can be more severely cold worked than alloy A.

Effect of annealing on tensile strength is shown in Fig 2. The alloys retain most of their strength up to about 600 F, and lose strength rapidly above that temperature. Although the graph shows the properties of the aluminum-free grades only, aluminum silicon bronze has similar characteristics.

Effects of temperature—Since these alloys soften rapidly at

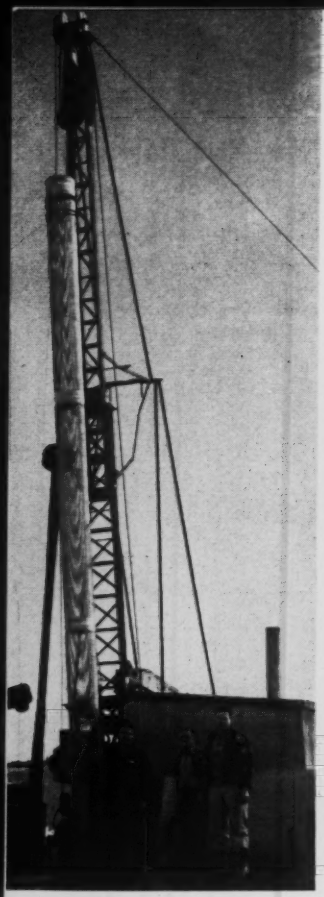
TABLE 1—COMPOSITION AND PROPERTIES

Commercial Type →	High Silicon Bronze (A)	Low Silicon Bronze (B)	Aluminum Silicon Bronze
Nearest ASTM Spec →	B96-58, B97-55, B98-58, B99-54, B124-55, B283-56, B315-58T	B97-55, B98-58, B99-54, B105-55	B124-55, B150-58, B283-56
Composition, %[a]	Cu 94.8 min, Si 2.8-3.8	Cu 96.0 min, Si 0.8-2.0[b]	Cu 89.0 min, Al 6.5-8.0, Si 1.5-3.0
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.308	0.316	0.278
Melting Temp Range, F	1880-1780	1940-1890	1840[f]
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	20	31	26
Coef of Ther Exp (68-572 F), per °F	10.0×10^{-6}	9.9×10^{-6}	10.0×10^{-6}
Specific Heat, Btu/lb/F	0.09	0.09	0.09
Elec Res (68F), microhm-cm	25	14	19
Mod of Elast in Tension, psi	15×10^6	17×10^6	16.0×10^6
MECHANICAL PROPERTIES			
Tensile Strength, 1000 psi			
Annealed Strip, Rod[e]	56-63	40[d]	85-90[d]
Annealed Tube	57	45	—
Hot Press Forging	52	—	83
Yield Strength (0.5% ext), 1000 psi			
Annealed Strip, Rod[e]	20-30	15[d]	44-60[d]
Annealed Tube	18	20	—
Hot Press Forging	18	—	41
Elongation (in 2 in.), %			
Annealed Strip, Rod[e]	55-63	50[d]	20-30[d]
Annealed Tube	70	55	—
Hot Press Forging	70[e]	—	35[e]
Hardness (Rockwell)			
Annealed Strip, Rod[e]	B35-66	F55-60	B74-90[d]
Annealed Tube	B45	F60-68	—
Hot Press Forging	B62	—	B77
Impact Strength (Izod, annealed strip, rod), ft-lb[c]	60-70[d]	60-70[d]	17[d]
Shear Strength (annealed strip, rod), 1000 psi[e]	42-45	—	45[d]

[a] One or more of the following elements may be present within the following limits:

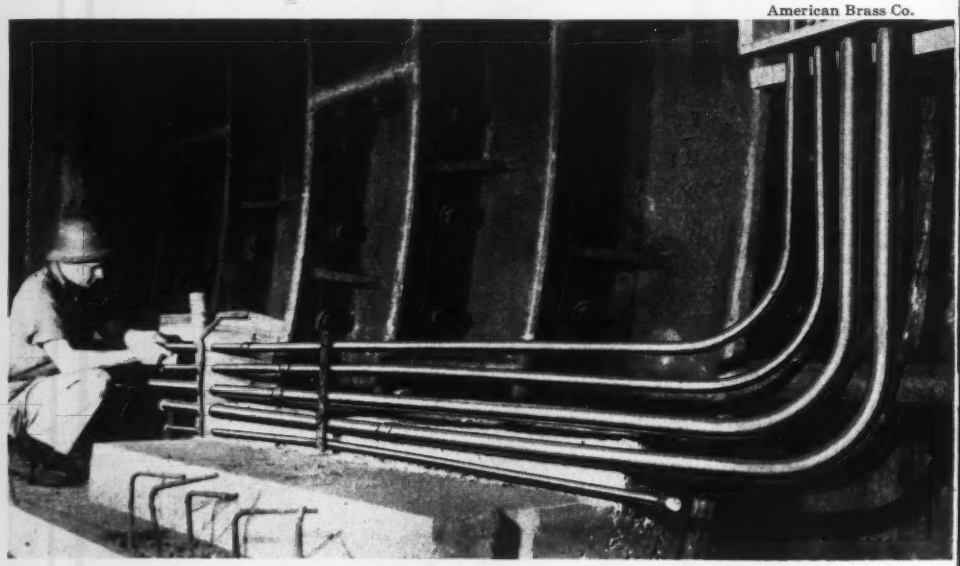
	Alloy A	Alloy B
Mn max	1.5	0.7
Zn max	1.5	—
Fe max	1.6	0.8
Ni max	0.6	—

[b] An alloy containing up to 2.6% Si is acceptable if the sum of all elements excepting Cu and Si is less than 0.3%.
[c] Varies with grain size.
[d] Rod only.
[e] Elongation in 4D.
[f] Solidus temperature not available.



Well screen, *16½ in. dia by 32 ft long, produced from silicon bronze for service in a 4,000,000-gal per day well.* American Brass Co.

Electrical conduit *is produced from silicon bronze for service under severe corrosive conditions such as found in the Brooklyn-Battery tunnel in New York City.* American Brass Co.



elevated temperatures, they are not suitable for service under stressed conditions above a working temperature of about 400 to 500 F. The limited long-time test data available, shown in Table 2, indicate that the alloys have good properties for service up to 500 F.

Data on low temperature properties are even more limited. Table 3 indicates that high silicon bronze A retains its ductility down to –175 F. Retention of ductility at low temperatures is a characteristic of all single-phase copper alloys and makes them suitable for service at subzero temperatures.

TABLE 2—ELEVATED TEMPERATURE PROPERTIES

Material and Condition	Temp, F	Yld Str (0.5% ext), 1000 psi	Stress (1000 psi) for Rupture in . . .		Creep Stress (1000 psi) for Creep Rate of . . .	
			100 Hr	1000 Hr	0.00001% Hr	0.0001% H
High Silicon Bronze A, Annealed	80	10.5	—	—	—	—
	300	4.7	—	—	23.0	29.0
	400	—	—	—	5.0	15.0
	500	—	—	—	1.7	4.2
	800	4.0	—	—	—	—
	1000	3.5	—	—	—	—
Low Silicon Bronze B, Annealed	75	13.3	—	—	—	—
	300	13.1	38.0	37.7	12.8	17.5
	400	12.7	34.0	28.5	4.9	12.8
	500	12.0	—	—	—	—
Low Silicon Bronze B, Cold Drawn 60%	75	66.5	—	—	—	—
	300	59.3	—	—	39.5	>50.0
	400	55.2	—	—	24.0	38.0
	500	48.2	—	—	—	—

Source: *Upthegrove.*

Corrosion resistance

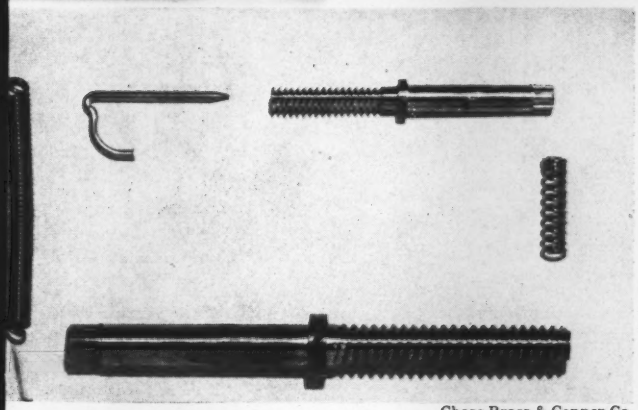
The silicon bronzes have corrosion resistance similar to that of copper in many environments. They have excellent resistance to corrosion by marine, industrial and rural atmospheres, to most types of fresh water, and to sea water under stagnant or low velocity conditions.

Silicon bronzes resist attack by hot and cold dilute sulfuric acid, cold concentrated sulfuric acid, cold dilute hydrochloric

TABLE 3—COLD IMPACT PROPERTIES OF HIGH SILICON BRONZE (A)

Temp, F	Charpy Impact Strength, ft-lb
68	66.4
0	80.1
–25	74.6
–110	69.2
–175	64.5

Source: *Smith, C. S.*

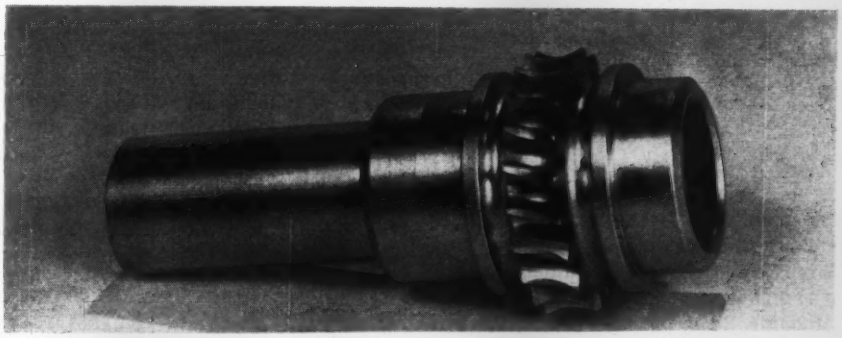


Chase Brass & Copper Co.

Coil springs, valve stems *and tube staples can be made from an age hardenable nickel silicon bronze in the soft condition and hardened by a subsequent low temperature heat treatment.*

American Brass Co.

Various screw machine products *are made from a high silicon bronze containing lead to improve machinability.*



Bridgeport Brass Co.

Worm driven screw *for aileron-operating mechanism on large airplane is made from aluminum silicon bronze because of its strength and resistance to wear.*

acid, and most organic acids. They are not resistant to oxidizing acids such as nitric and chromic.

These alloys are resistant to hot and cold dilute alkalis, such as sodium and potassium hydroxide, and to cold concentrated alkalis. They are not resistant to ammonium hydroxide.

They are resistant to chlorides and sulfates of the light metals, such as aluminum, sodium and potassium, but are less resistant to those of the heavy metals, e.g., iron. Like copper the silicon bronzes are attacked by sulfides, particularly at elevated temperatures.

The high silicon bronzes are much more resistant to stress-corrosion cracking than the brasses. Low silicon bronze and aluminum silicon bronze have excellent resistance to this type of corrosion. High silicon bronze is less resistant. To minimize the hazard of stress corrosion cracking, it is sometimes advisable that fabricated parts be stress-relief annealed before being placed in service.

In all work involving corrosion, remarks on relative resistance are only qualitative. Before selecting an alloy for a specific service, tests should be made under actual service conditions.

Fabricating characteristics

Here is a brief survey of the processing characteristics of the standard alloys (see also Table 4).

Hot working—All of the standard silicon bronzes have excellent hot working properties. They can be rolled, extruded, formed, bent or forged at elevated temperatures.

Cold working — Low silicon bronze B has the highest ductility of the three standard types and as a result has the best cold working properties. It was developed

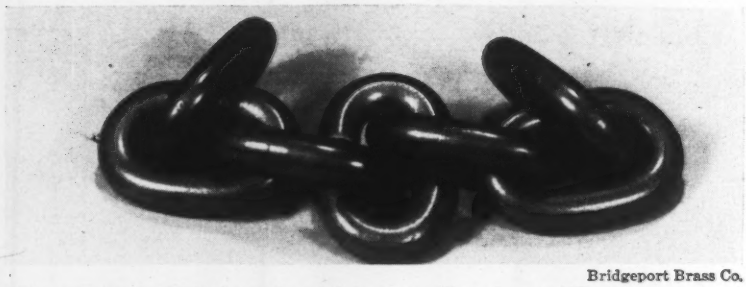
TABLE 4—FABRICATING PROPERTIES

Alloy →	High Silicon Bronze (A)	Low Silicon Bronze (B)	Aluminum Silicon Bronze
Cold Workability	Excellent	Excellent	Poor
Hot Workability	Excellent	Excellent	Excellent
Hot Working Temp Range, F	1300–1600	1300–1600	1300–1600
Annealing Temp, F	900–1300	900–1250	1100–1125
Machinability Rating (free-cutting brass = 100)	30	30	60
Joining Characteristics			
Soft Soldering	Good	Good	Not recommended[1]
Silver Alloy Brazing	Excellent	Excellent	Fair
Oxyacetylene Welding	Excellent	Excellent	Poor
Carbon Arc Welding	Excellent	Excellent	Fair
Gas Shielded Arc Welding	Excellent	Excellent	Fair
Metal Arc Welding	Fair	Fair	Fair
Resistance Welding	Excellent	Good	Fair

[1] Can be soldered with special techniques.

Bridgeport Brass Co.

Valve stem *of low silicon bronze (B) provides wear and corrosion resistance with high strength for service under high pressure, corrosive conditions.*



Bridgeport Brass Co.

Mine sweeper chain *is produced from low silicon bronze (B) to take advantage of its nonsparking and nonmagnetic properties. Chain is welded with a high silicon bronze filler metal.*

for operations involving severe cold working. High silicon bronze A is stiffer than the lower alloyed type and is more difficult to work, although its properties make it suitable for many cold forming operations. Both of these alloys can be blanked, formed, swaged and bent cold. Typical bend angles for alloy A are given in Table 5. Aluminum silicon bronze is essentially a hot working alloy and is suited only for limited cold working.

All three of the alloys can be annealed at temperatures of 900 to 1300 F, the temperature depending on the alloy and the final properties desired.

Machining—The relative machinability of copper alloys is indicated by comparison with free-cutting brass, most readily machined of the copper alloys. Based on a rating of 100 for free-cutting brass, aluminum silicon bronze has a machinability rating of 60, and the other two standard silicon bronzes have ratings of 30. These ratings place aluminum silicon bronze in the readily machinable group. The other two alloys are considered moderately machinable. Tools, coolants and speeds used in machining the nonleaded brasses are satisfactory for machining the silicon bronzes.

Joining—The silicon bronzes can be welded, brazed and soldered. Suitability of various processes is summarized in Table 4.

Silicon bronzes are among the easiest of the copper alloys to weld partly because they have low thermal conductivity. Since the alloys are poor conductors of heat, speed of welding is high and preheating is usually unnecessary.

Silicon bronzes A and B are readily welded by the inert gas arc processes using filler metal of the A composition. These are the preferred and most widely used processes because they insure maximum soundness and mechanical properties in the joints. The carbon arc process may also be used but is now employed only when it is not essential to develop maximum joint properties. These silicon bronzes are also readily joined by resistance spot, seam and butt welding. Energy requirements are much lower than for most other copper alloys and only slightly higher than for equivalent thicknesses of low carbon steel.

Silicon bronzes A and B can be readily brazed provided sufficient flux is used to prevent formation of refractory oxides. Standard silver alloy filler metals are suitable. The alloys are subject to intergranular penetration of the filler metal if the parts are under stress; parts should be stress relieved before brazing.

Silicon bronzes A and B can be joined with the standard grades of solder, if certain precautions are observed. The surface should be cleaned mechanically before soldering or by pickling in a sodium dichromate solution. Fluxes such as hydrochloric acid-zinc chloride or various proprietary compositions must be used to prevent formation of refractory oxides. Resin fluxes are not active enough to serve satisfactorily. Solder is preferably 63 tin-37% lead or 60 lead-40% tin. Soldering should be done as soon as possible after cleaning. Under these conditions, joints are made easily.

TABLE 5—RECOMMENDED BEND RADII FOR HIGH SILICON BRONZE SHEET (A)[a]

Condition	Tensile Strength, 1000 psi	Rockwell Hardness	Min Suitable Radius of Punch, in.		
			90-Deg Bend Perp to Rolling Direction	90-Deg Bend 45 Deg to Rolling Direction	90-Deg Bend Par. to Rolling Direction
Cold Rolled, 37% Reduction...	87-97.....	88-96.....	1/32	1/32	1/16
Cold Rolled, 60% Reduction...	105-113....	94-99.....	3/64	3/32	3/16

[a]Nominal thickness of sheet, 0.020 in.
Source: *Gohn.*

Applications

In addition to strength, ductility and weldability, these alloys are nonmagnetic and non-sparking —significant properties for certain applications.

Some uses of the various types of silicon bronzes are discussed below. Other applications are shown in the accompanying illustrations. These are by no means the only applications of the alloys and are merely indicative of the various fields in which they have been employed.

High silicon bronze A—This type of silicon bronze has established itself in many fields of application.

• One of the largest uses for sheet, strip and plate is in the welded construction of unfired hot water storage heaters from domestic sizes up to tanks of 20,000-gal capacity. Resistance to corrosion under a wide range of conditions leads to the use of high silicon bronze A for heat exchangers, distilling and evaporating units, and sugar processing and paper mill equipment.

• Other uses of flat products: fire extinguisher shells, outdoor signs, washers, clutch disks for bicycles, bearing plates, screen plates and pole line hardware.

• Flat springs of alloy A can sometimes be used to replace similar phosphor bronze springs for electrical snap switches and control instruments if the spring movement is not too great.

• Rod and wire have many applications in hot headed fasteners of various types, such as long bolts and irregular-shaped parts. Welding rod is an important use.

• Cast fittings and seamless pipe or tube are used in petroleum refining equipment handling corrosive solutions, for aircraft hydraulic pressure lines, and for heat exchanger tubes.

Low silicon bronze B—This type of silicon bronze was developed especially for manufacturing operations involving severe cold working. As a result, low silicon bronze can withstand considerably more cold working than many other copper alloys and generally does not require stress-relief annealing to prevent stress-corrosion cracking.

• Production of cold headed products from rod and wire is a major use of this alloy. Among products are cap and machine screws, wire and cable connectors, pole line hardware, marine hardware and valve components. Screws and nails are widely used in construction of yachts and motorboats.

• Sheet and strip are used in production of wire and cable connectors and electrical fittings.

• Tubing and pipe are used for hydraulic pressure lines in aircraft, heat exchanger tubing and instrument tubing. The alloy is malleable and can be flared and bent readily.

Aluminum silicon bronze—This alloy is one of the strongest of the readily machinable nonferrous alloys and can be hot forged to strengths of about 90,000 psi. It is not suitable for cold working and is fabricated by hot forging or pressing.

• Hot forged or pressed parts are used for valve components to handle steam, compressed gases and liquids; acetylene welding equipment; aircraft compression fittings, gears and pinions; large bolts and nuts; and pole line hardware such as suspension clamps and strain connectors. Cored forgings are also produced from this alloy; applications include caps, gage bodies, and high pressure valve bodies and heads.

• An advantage of using aluminum silicon bronze nuts with brass studs or bolts is their resistance to seizure when drawn up tight and exposed to the atmosphere. These connectors can be released and retightened without difficulty.

• Aluminum silicon bronze can be used to advantage for slow-moving sliding parts and for rollers in such applications as tube reducing machines. The alloy is not a bearing material like the leaded bronzes and is not suitable for bushings to be used on shafts rotating at high speeds.

• This bronze has the best machinability of all silicon and aluminum bronzes and is used for the production of many machined parts. Included are valve components, sleeves for compressor fittings, components for wire and cable connectors, and pump parts for high pressure hydraulic systems.

Precipitation Hardenable Silicon Bronze

A precipitation hardenable alloy containing nominally 0.6 silicon-1.9 nickel-97.5% copper has been made available recently by Chase Brass & Copper Co. The principal attributes that distinguish this alloy from the standard grades are:

1. *Precipitation hardening.* Rod or wire supplied by the mill in the cold forming temper can be severely cold worked. The fabricated part can then be precipitation hardened at 700 to 850 F to develop tensile strength of about 100,000 psi.

2. *High yield strength.* In the precipitation hardened condition, the alloy develops yield strengths greater than 80,000 psi. The standard alloys develop yield strengths in the hard condition of 50,000 to 55,000 psi.

3. *Conductivity.* Electrical conductivity increases to about 30% after hardening. This value contrasts with about 6 to 12% for the standard alloys and is advantageous in certain electrical applications.

The general corrosion resistance of the precipitation hardened alloy is comparable with that of the standard grades. Under stressed conditions the hardened alloy is resistant to stress-corrosion cracking.

In general, this alloy has applications similar to those of the standard grades

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Acknowledgments

The assistance of the following organizations in preparing this article is gratefully acknowledged:

American Brass Co.
Bridgeport Brass Co.
Chase Brass & Copper Co.
Copper & Brass Research Assn.
Revere Copper and Brass, Inc.

AN EDITORIAL

Let's Stop Over-Designing

by G. K. Manning,
Chief, Metallurgical Engineering Div., Battelle Memorial Institute

Have you heard of the wonderful one-hoss shay,
That was built in such a logical way
It ran a hundred years to a day,
And then, of a sudden it—ah, but stay . . .

. . . What do you think the parson found,
When he got up and stared around?
The poor old chaise in a heap or mound,
As if it had been to the mill and ground!
You see, of course, if you are not a dunce,
How it went to pieces all at once—
All at once and nothing first—
Just as bubbles do when they burst.

There was no waste here. Every component was perfectly designed to have precisely the same life as every other component. The "one-hoss shay" represented perfection in design that no manufacturer will ever achieve, but the principle involved is worth keeping in mind. Many of the mechanical devices we use contain a host of "over-designed" components. These over-designed components represent extra initial cost that adds nothing to the usefulness of the product.

One culprit: the 'safety' factor

A large part of the waste associated with overdesign is perpetrated by the unquestioned use of conventional safety factors. It is too bad that the word "safety" ever came to be associated with such factors. "Safety" carries with it a moral connotation that discourages any attempt toward re-evaluation. Perhaps if the more forthright term "ignorance factor" had come into common use it would be easier to assume an objective attitude. But, alas, there seems little hope of changing such a time-worn bit of terminology.

Many of the safety factors used by designers today were established more than 50 years ago. Technology has made great progress during the last 50 years. A safety factor of three may have been quite reasonable in 1900, yet be quite unreasonable today. The mechanical properties of metals were far less subject to control then than they are now. The safety factor was one way of making allowance for the occasional "weak sister" which at that time could not be detected. Furthermore, very little was known about the stress concentrating effect of notches, and about the only nondestructive method of finding defects was visual examination.

Closer control of properties today

Today, the situation is different. It is possible, with a minimum of quality control, to obtain tensile strengths that are consistently within $\pm 10\%$ of the intended value. The aircraft industry has been successful in working to even closer limits than this.

We know a great deal about the extent to which notches and changes in section concentrate stress. Designers should be able to calculate maximum actual stress with confidence in many cases.

Even if stresses cannot be calculated, they can be determined experimentally by use of electric strain gages or photoelastic studies. There are a number of nondestructive test methods available, such as radiography, ultrasonics, magnetic particle, and superficial hardness, which may be used to insure uniformity of product and freedom from defects.

No one gains from excess weight

Safety factors of three or five (in some cases more) are inconsistent with the present state of technology. The user of a piece of equipment gains nothing because a shaft is three times as strong as it need be. On the contrary, the unnecessary weight may add to his cost of operation.

And the producer gains nothing either; in fact he would probably have enjoyed a more comfortable profit margin had he made full use of modern technology and insisted that his designers give recognition to the principle of the one-horse shay.

Aircraft industry more realistic

The aircraft industry has pioneered in assuming a realistic attitude toward safety factors, undoubtedly because of the severe penalty excess weight places on the operational cost of aircraft. It has been common practice to use safety factors of 1.5 and, in some cases, even less for many aircraft components during the last 20 years. Reliability of performance has not been sacrificed as attested by the fact that more and more people travel by air each year.

A good many missile components are designed with the theoretical maximum stress equal to the yield strength of the material. The only safety factor that exists is the difference between yield strength and ultimate strength (perhaps 1.15). This is not an appropriate time to comment about the reliability of missiles, but there is little doubt that in the course of a few years satisfactory reliability will be achieved.

The case of the cast iron roll

An interesting example of waste came to light not long ago. A piece of heavy machinery had, as one component, a massive cast iron roll. Forty years ago when the first machine was built, the designer had evidently been a cautious soul and decided that a safety factor of 10 was necessary, or at least desirable. Through many design modifications the roll became longer and longer and, consequently, heavier and heavier. There were no roll failures, there were no customer complaints. The safety factor of 10 came to be looked on as a magic number: it guaranteed trouble-free operation.

But the roll diameter increased, through the years, as approximately the square of the length. Finally the roll became so massive that it was impractical to cast.

Only then was the designer willing to reconsider the design procedure and look with doubt at his time-tested safety factor. It would be difficult to estimate how many materials dollars were wasted during the last 40 years in producing the roll.

How many ghosts do you have in your closet?

TABLE 1—ELASTIC MODULI AS DETERMINED BY THREE TESTING METHODS
(1000 Psi and Gm per Denier)

Material ↓	Extensometer	ASTM Spec[a]	Sonic[b]	Material ↓	Extensometer	ASTM Spec[a]	Sonic[b]
FILM[c]				PAPER[c]			
Polyester (Mylar)	745-755	630	710-780	Kraft (40-lb)	840-850	800	830-870
Polyvinyl Chloride (semi-rigid)	590-610	500	560-630	Moistite	530-540	460	510-570
Cellophane	445-455	330	410-490	Paperboard (100-lb)	530-535	520	530-580
Cellulose Acetate	435-445	377	426-450	Map	490-500	460	485-535
Vinylidene Chloride (saran)	171-173	120	171-183	Snowtex	440-450	370	420-500
TFE Fluorocarbon (Teflon)	160-165	110	—	YARN (continuous filament)			
Polyvinyl Chloride (nonrigid)	40-42	40	40-51	Glass	345-355	260, 345[e]	330-370
Polyvinyl Chloride-Acetate (non-rigid)	36-37	36	36-38	Polyester (Dacron)	122-124	102, 120[e]	121-128
Polyethylene (polythene)	19-21	20	19-24	Polyamide (nylon)	64-66	46, 51[e]	61-68
SHEET[c]				Regenerated Cellulose (rayon)	51-53	43, 51[e]	49-54
Polyvinyl Chloride (rigid)	500-510	300	480-520	YARN (spun)[d]			
Polyvinyl Chloride-Acetate (non-rigid)	3.6-3.7	3.6	3.5-3.8	Egyptian Cotton	91-93	80, 88[e]	90-95
				American Cotton	37-38	17, 18[e]	36-39
				Wool	6.7-6.9	4.7, 5.4[e]	6.4-6.9

[a]Plastics film and sheet, D882-54T; commercial papers, D828-48; woven fabrics, D39-49. All specimen lengths are 4 in. unless otherwise indicated.
[b]The sonic method is a laboratory test of the sample or basic polymer, made by measuring the velocity of sound pulse propagation between electronic crystals, with and without the sample. It yields the highest modulus obtainable.
[c]Units for sheet, film and paper are 1000 psi.
[d]Units for yarn values are gm per denier.
[e]Second value is for a 12-in. specimen.

Better Modulus Values for Low-Tensile Materials

A new extensometer provides accurate values of the modulus of elasticity of films, papers and yarns, and reveals the invalid assumptions of previous methods.

by J. K. Owens, *New Products Div., E. I. du Pont de Nemours & Co., Inc.*

■ The table above gives the results of three methods of testing low-tensile materials. The sonic values—determined by costly laboratory tests and generally accepted as the true moduli—show that the extensometer test is more accurate than the ASTM or other methods. The ASTM and similar methods assume that the specimen is elongated at a strain rate dependent only on the crosshead speed of the testing machine.

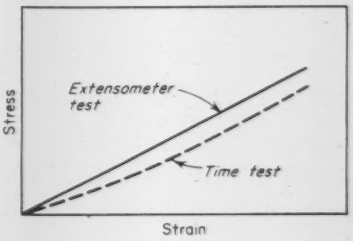
Extensometers have long been used on metals and rigid materials, but no type existed that could be made weightless and also be effectively attached to fragile materials without causing buckling or fracturing. Tinius Olsen Testing Machine Co. has recently developed such an extensometer and believes that previous test methods—which were probably adapted from methods of testing textile fibers—can be considered outmoded.

The extensometer should be particularly valuable in determining the modulus of elasticity, or stiffness, of plastics films. With accurate values of the modulus, designers should be able to select materials and thicknesses to meet specifications that will, for the first time, have validity in terms of end use. Packaging, furniture, toys and automobile seat covers are examples of products which should benefit.

The ASTM tests were conducted on both Instron and Tinius Olsen machines without significant variation in the results obtained. The extensometer tests were conducted on a new Olsen XY Electomatic machine providing a 4000:1 spread of testing ranges.

Why the extensometer is more accurate

Only the extensometer method yields the true stress-strain curve for an elastic material—one that is a straight line even at low loads. Previous methods, which can be referred to as "stress-time" rather than "stress-strain," yield a nonlinear initial curve as shown below.

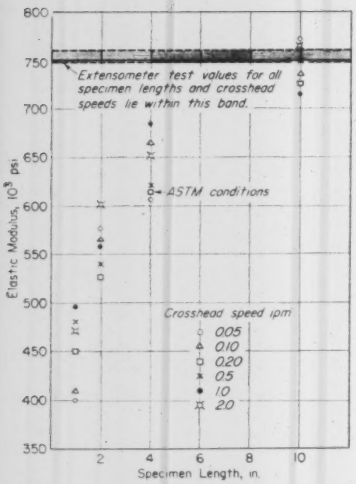


Other investigators have reported this inconsistency (Olsen and Vanas, *ASTM Bulletin*, Jan '57).

The stress-time method assumes that strain takes place at the same rate that the crosshead moves. There are three factors which may invalidate this assumption:

1. Jaw grip slippage.
2. Specimen length.
3. Strain rate or crosshead speed.

It is obvious that jaw grip



Elastic modulus *of Mylar as determined by the extensometer method and by stress-time methods. Only with a 10-in. specimen is an accurate value obtained unless the extensometer is used, yet 4 in. is the generally accepted test length.*

slippage will affect the modulus values. The effects of the other factors on stress-time tests are shown in the graph which reports the results of tests on Mylar film. The extensometer, on the other hand, yields consistent values regardless of specimen length or crosshead speed. This is because the extensometer determines the true strain of the material.

Data show how these factors affect conventional tests

Additional tests were made to point out the effect of factors which led to inconsistant moduli determinations in the past.

Jaw grip slippage—Table 2 gives the results of some of the jaw grip tests as an example of the effect that slippage can have on the modulus determination. Jaws faced with dental dam rubber, neoprene rubber, hard rubber, chipboard, emery paper and crocus cloth, as well as serrated jaws partially covered with masking tape, were used. In all cases there was some slippage which resulted in a decrease in stress and an erroneously recorded increase in specimen length. Although the amount of slippage varied with different grips, none of the grips were satisfactory, particularly for testing plastics films.

Specimen length—The following data indicate the large variation in moduli values obtainable by standard test procedures:

Specimen Length, in.	Modulus, 1000 psi
1	400
2	560
4	620
10	750

In general, the greater the specimen length (which with standard tests is equal to the distance between the machine jaws), the higher the value of modulus determined. This is true up to about 20 in.; for greater lengths the value is constant and equal to the modulus obtained by the extensometer method.

The shortest length that will yield an accurate value of the modulus actually varies with the material. For Mylar polyester film, as can be seen from the graph on this page, the minimum length is 10 in. But there is no way to determine the minimum length of a material beforehand, and thus the extensometer method is recommended. The commonly accepted specimen length for plastics films and papers is 4 in., which in most cases results in too low a modulus determination.

TABLE 2—HOW GRIP AFFECTS MODULUS

Grip Type ↓	Modulus of Elasticity, 1000 Psi	
	Brass Shim	Polyester Film
Rubber	9,970	550
Serrated	10,500	585
Diamond Serrated	13,500	605

TABLE 3—HOW STRAIN RATE AFFECTS MODULUS (Polyester Film)

Strain Rate, %/min	Crosshead Speed, in./min	Modulus, 1000 psi
SPECIMEN LENGTH = 4 IN.		
5	0.2	616
12.5	0.5	620
25	1.0	712
50	2.0	650
SPECIMEN LENGTH = 10 IN.		
1	0.1	720
2	0.2	784
5	0.5	815
10	1.0	752
20	2.0	742

Strain rate or crosshead speed—Table 3 shows that strain rate, which is varied by changing the crosshead speed and using the same specimen length, has a minor effect on the modulus as compared with jaw slippage and specimen length. The effects of different crosshead speeds also depend upon the material. Tests on aluminum foil, for example, show no appreciable difference in moduli obtained at different crosshead speeds.

An attempt was also made to evaluate the use of an extensometer on materials with very high elongation. A vinyl film with an elongation of 250% was tested using various lengths and crosshead speeds, as well as with and without the extensometer. All results were approximately the same, probably because the film stretches at a very low stress, and therefore very little strain is imposed on that portion of the specimen within the grips.

The extensometer

A number of problems had to be overcome in designing an extensometer for use with fragile materials such as plastics films. The gripping surface had to be small, yet not cut through the materials. At the same time the force exerted had to be sufficient to prevent slippage. In addition, there had to be no effective weight supplied by the instrument, and the force required to activate it had to be held to a minimum.

The extensometer designed by Tinius Olsen requires only 0.5 gm to activate the jaws. The gripping surface is flat, 0.0005 in. in width. The instrument is provided with three strain magnifications. A counterbalancing device eliminates the weight and moves so that the extensometer will be parallel with the specimen as they move down together.

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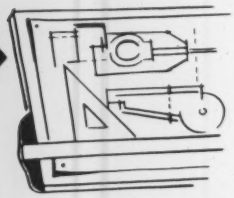

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Toughness and transparency *called for use of butyrate for Philco TV picture-screen shield.*

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Toughness at low and high temperatures *is one reason for using nylon in GE refrigerator door latch.*

Rohm & Haas Co.

Toughness and stain resistance *are required for modified acrylic, RCA TV remote control housing.*

Dow Chemical Co.

Toughness and low cost *helped point to use of impact styrene for Stromberg-Carlson plant paging receiver.*

Materials
in Design Engineering

Manual No. 164
November 1959

Impact Thermoplastics: Which One to Use

In planning a thermoplastic product, what material gives you the necessary toughness at the lowest possible cost—and still has the other important properties you need, such as rigidity, weatherability or attractive color? This guide, an extensive comparison of all impact resistant thermoplastics, is a unique attempt to answer that question for you, or at least reduce your choice to a maximum of two or three possible materials.

by Malcolm W. Riley,
Associate Editor, Materials in Design Engineering

■ The ability of a plastic to withstand impact or shock loading is one of the most difficult properties to measure. Test conditions usually bear little resemblance to service conditions (see box on p 128). Nevertheless engineers are often faced with the problem of selecting a plastic for a part—whether it be a toy or a rapidly engaging gear—that will be subjected to some kind of shock or impact loading.

In addition to toughness, each part requires certain other properties, such as heat resistance, chemical resistance, dimensional stability or colorability. The problem of selecting the thermoplastic with the necessary balance of these properties—at the right price—is a complex one.

The majority of "impact resistant" thermoplastic materials are now selected by a two-step process: First, the engineer studies the design in question and on the basis of his experience decides that one or two types of materials might meet his requirements. Next, he usually makes some type of simulated service test to find out which material can really do the job. Unfortunately, too few plastics engineers have broad experience in thermoplastics. Consequently, selection of the proper material may often turn out to be a costly hit-or-miss, trial-and-error operation.

How to use this manual

This manual is intended as a screening guide to be used during the initial materials evaluation stages. All of the 10 major families of thermoplastic materials discussed here are available in grades with notched Izod impact strengths of about 2 or more ft-lb per in. notch. The first section of the article discusses the materials, outlining very briefly their major attributes and their general chemical resistance. The second section takes up separately the various end properties of interest, as well as cost; it provides comparative ratings of all the thermoplastics.

After determining the most important properties required of your part, study the property and cost comparisons. Considering the distinct attributes of the various materials and their costs, you should be able to quickly screen out certain materials that will not meet your design requirements, and narrow final selection down to possibly one, more likely two or three, most promising materials.

At that point, consultation with both your molder and the materials supplier will further confirm or narrow your choice. Finally, you should evaluate the part in service or under closely simulated service conditions to make sure the material selected is the proper one.

Another factor that must be carefully considered is the method by which the part will be produced. Method of production has an important effect on both cost and the actual properties obtained in the final part. Often the method is clearly dictated by the design of the part; other times not. The box on p 132 discusses the various methods of producing impact thermoplastic parts.

The materials: a brief summary

Following are thumbnail sketches of the impact thermoplastics covered in this article. The materials are discussed in general order of decreasing impact strength. The discussions only outline outstanding attributes and commonly reported chemical resistance. Specific property ranges obtainable are discussed in the next section, where detailed comparisons with other materials are made in the form of bar charts.

Plasticized polyvinyl chloride is not covered here. It is a highly flexible material which can be made available with a variety of other properties, depending on formulation. In general, it is low cost, has relatively high chemical resistance, is self-extinguishing or slow burning, and has excellent characteristics for use as electrical insulation.

Polyethylenes

Polyethylenes are classified by density as follows: type I—0.910-0.925 gm per cu cm; type II—0.926-0.940 gm per cu cm; type III—0.941-0.965 gm per cu cm. Second only to polystyrenes in low cost, the three types of polyethylenes have in common: 1) toughness, 2) near zero moisture absorption, 3) excellent chemical resistance, 4) excellent electrical insulating characteristics, 5) a waxy feel, and 6) coloring possibilities ranging from translucent pastels to bright opaques.

In rigidity, the materials range from highly flexible type I low density resins (no break in Izod impact test) to relatively rigid type III materials. Increasing density increases rigidity, temperature resistance and load carrying ability.

Polyethylenes have excellent resistance to acids (except oxidizing) and alkalis at normal temperatures. Below 122 F they are insoluble in organic solvents; at higher temperatures they are soluble to varying degrees in hydrocarbons and halogenated hydrocarbons, but insoluble in more polar compounds. The higher density materials generally have somewhat better chemical resistance.

Polycarbonates

Though among the highest cost thermoplastics, these new materials feature an exceedingly high impact strength coupled with high strength and rigidity. They also have 1) excellent heat resistance, 2) high resistance to creep, and 3) good fatigue strength. Colorability is excellent.

Polycarbonates are resistant to

mineral and organic acids, and water; insoluble in aliphatic hydrocarbons, ether and alcohols; and partially soluble in aromatic and chlorinated hydrocarbons. They are slowly decomposed by alkaline materials.

Rigid PVC (type II)

Moderate in cost, type II (rubber-modified) rigid polyvinyl chloride offers an excellent balance of toughness, strength and abrasion resistance, coupled with 1) excellent chemical resistance, 2) excellent electrical insulating characteristics, 3) noninflammability, 4) nontoxicity, and 5) unlimited colorability. The materials are quite limited in heat resistance.

Rigid PVC has excellent resistance to 10% caustic, pickling acid, plating baths, hydrofluoric acid, chromic acid, and other acids and bases in general, except for 93% or higher sulfuric acid and glacial acetic acid. PVC does not resist ketones, esters or chlorinated hydrocarbons.

Impact polystyrenes

Rubber-modified polystyrenes are the lowest in cost of the impact thermoplastics. They have virtually unlimited colorability, but cannot be produced with crystal clarity. They have excellent electrical insulating characteristics. Glass-filled molding compounds provide increased strength and durability.

Polystyrenes have good resistance to alkalis, salts, lower alcohols, glycols, and water; fair resistance to mineral and vegetable oils; and are soluble in aromatic and chlorinated hydrocarbons. They are softened or attacked by higher alcohols, gasoline, strong oxidizing acids, and chlorine and bromine waters.

Cellulosics

Cellulose acetate, cellulose acetate butyrate, cellulose propionate and ethyl cellulose have in common toughness, colorability and ease of fabrication. They are all moderate in cost; acetate is least expensive, ethyl cellulose most expensive of the four. Acetate, propionate and butyrate are available in grades ranging from soft to hard—from tough resilience to high rigidity. Self-extinguishing grades of acetate are available. The materials can be crystal clear or colored to any degree.

In general, butyrate is somewhat tougher than acetate, and has somewhat better dimensional stability. Butyrate has good weatherability.

Propionate is similar to butyrate, though it has somewhat higher impact strength.

Ethyl cellulose is primarily noted for its high impact strength at temperatures as low as –50 F.

Cellulose acetate is not attacked by water, salt water, white gasoline, oleic acid, or dilute sulfuric acid. It is decomposed by 30% sulfuric, 10% nitric and 10% hydrochloric acids; sodium hydroxide; and 10% ammonium hydroxide. It is dissolved by acetone and ethyl acetate.

Butyrate and propionate are not seriously affected by 30% sulfuric, 5% acetic, 10% hydrochloric, or oleic acids; they are discolored by 10% nitric acid. They are not affected by white gasoline, but are swollen or dissolved by ethyl alcohol, acetone, ethyl acetate, ethylene dichloride, carbon tetrachloride and toluene. They are also unaffected by fresh or salt water, and 3% hydrogen peroxide.

Ethyl cellulose is not affected by 3% sulfuric, 5% acetic or 10% hydrochloric acids; 10% sodium hydroxide; 2% sodium carbonate; or water. It is slightly affected by 30% sulfuric and 10% nitric acids; and 10% ammonium hydroxide. It is attacked by 95% ethyl alcohol, acetone, toluene and gasoline.

ABS materials

Consisting of acrylonitrile, styrene and butadiene, ABS materials have as their major attribute an excellent balance of toughness, strength, rigidity, low and high temperature stability, and weatherability. Colorability is excellent.

ABS materials are highly resistant to aqueous acids, alkalis and salts. They also resist concentrated phosphoric and hydrochloric acids, alcohols, and animal, vegetable and mineral oils. They are disintegrated by concentrated sulfuric and nitric acids, and soluble in esters, ketones and ethylene dichloride.

Fluorocarbons

TFE and CFE fluorocarbons are unexcelled in chemical inertness, heat resistance (when not stressed), and low temperature stability. TFE exceeds CFE in these characteristics, but CFE is the stronger material. Both materials have extremely low coefficients of friction, and excellent electrical insulating characteristics.

TFE is not a true thermoplastic, and must be molded by a compacting and sintering process. CFE can be molded by conventional thermoplastic forming techniques, though at relatively high temperatures. These materials are the highest cost thermoplastics.

TFE is inert to virtually all corrosive chemicals and solvents. Halogenated solvents at high temperatures and pressures may have some effect. CFE is impervious to corrosive chemicals, and highly resistant to most organic solvents. Swelling may occur with highly halogenated and aromatic compounds, but the reaction is reversible.

Nylon

Among the strongest of the thermoplastics, nylons have good abrasion resistance, low friction characteristics, relatively high heat resistance, and reasonably good electrical insulating characteristics at commercial power frequencies. They have relatively high moisture absorption, and properties are sensitive to moisture content. They are relatively expensive materials.

Nylons are resistant to most solvents and particularly resistant to petroleum oils and greases, alkalis, lactic acids and photographic solutions. They are generally soluble in molten phenol and hot formic acid. They are attacked by concentrated solutions of mineral acids.

Modified acrylic

The modified high impact acrylic is hard and scratch resistant, and provides a high surface gloss.

TABLE 1—PROPERTIES OF

Rating Range →	Qualitative Comparisons[a]								
	Mechanical Strength				Heat Resistance (stressed)		Electrical Properties		Cost, lb-value basis
	Notched Impact Str (1-18)	Flex Mod of Elast (1-18)	Ten Str (1-16)	Elong (1-18)	66 Psi (1-20)	264 Psi (1-20)	Vol Res (1-14)	Dielec Str (1-11)	(1-17)
HIGH IMPACT MATERIALS (> 5 ft-lb/in. notch)									
Polyethylene (type I)	NB	—	16	1	20	—	2	3	2
Polyethylene (type II)	NB	—	15	2	19	—	2	3	4
Polycarbonate	1	7	4	7	4	2	5	9	12[c]
Rigid PVC (type II)	2	5	8	13	16	15	12	1	8
Polystyrene (high impact)	3	5	10	12	14	8	3	4	1
Propionate	4	10	10	9	12	7	9	8	7
ABS (high impact)	5	9	7	10	7	4	4	10	8
Ethyl Cellulose (high impact)	6	14	9	16	12	16	12	6	11
Ethyl Cellulose (Gnl Purp)	7	10	8	15	10	14	12	6	11
Acetate (soft)	8	12	12	10	18	20	13	11	6
Butyrate (soft)	8	17	13	8	17	19	14	10	7
Polyethylene (type III)	9	13	11	7	15	13	2	3	3[b]
IMPACT MATERIALS (< 5 ft-lb/in. notch)									
Butyrate (medium-hard)	10	15	10	8	13	12	14	10	7
Polystyrene-Glass	11	—	2	18	9	5	11	—	10
Acetate (medium)	12	8	9	11	14	10	13	11	6
TFE Fluorocarbon	12	16	14	3	5	17	1	9	16
CFE Fluorocarbon	13	14	12	6	—	—	1	7	17
Nylon-Glass	14	1	1	17	1	1	7	—	15
Polystyrene (impact)	15	2	7	15	11	8	3	4	1
ABS (impact)	15	3	6	7	7	4	4	10	8
Acetate (hard)	16	5	6	14	6	3	13	11	6
Nylon[b]	17	6	3	4	2	9	8	5	13
Modified Acrylic	17	11	10	15	13	11	5	6	9
Acetal	18	4	5	16	3	6	10	5	14
Polypropylene	18	18	11	5	8	18	6	2	5

[a]Range of ratings is shown; 1 = most desirable, 2 = next most desirable, etc. NB = no break. Lowest values in cost column indicate lowest cost materials.

[b]Equilibrium moisture content in air.
[c]Shore D scale.
[d]Stress at yield.
[e]Self-extinguishing grades are available.

Clarity ranges from translucent to opaque, and a wide range of opaque colors are available. Acrylic has high dimensional stability and good resistance to staining and weathering.

The material is resistant to weak alkalis, acids and aliphatic hydrocarbons. It is attacked by esters, ketones, aromatic and chlorinated hydrocarbons, and concentrated acids.

Acetal

The new acetal resin (polyformaldehyde) has mechanical characteristics similar to those of nylon, but is somewhat more rigid and less ductile. It has outstanding fatigue life. Its heat resistance is similar to that of nylon. It has good electrical insulating characteristics at commercial power frequencies, and low frictional characteristics. Like nylon it is a relatively high cost material.

Acetal has outstanding resistance to most organic solvents, including aliphatic and aromatic hydrocarbons. It is not recommended for use with strong acids and alkalis; it should be tested for use with dilute acids and weak alkalis.

Polypropylene

A relatively low cost material, isotactic polypropylene is somewhat similar in nature to type III polyethylene, but is lighter in weight and has greater rigidity, strength and heat resistance. Polypropylene has negligible water absorption, excellent chemical resistance, and extremely high resistance to environmental stress cracking. It has excellent electrical insulating characteristics and a wide range of colorability.

Polypropylene is resistant to most acids, alkalis and saline solutions, even at elevated temperatures. It is resistant to organic solvents and polar substances. Above 175 F, polypropylene is soluble in aromatic substances such as toluene and xylene, and chlorinated hydrocarbons such as trichlorethylene.

Some Typical Properties								
Mean Specific Gravity (D792)	Rockwell Hardness (D785)	Flexural Strength (D790), 1000 psi	Compressive Strength (D695), 1000 psi	Coef of Ther Exp (D696), 10^{-5} per °F	Ther Cond (C177), Btu/hr/sq ft/ °F/ft	Water Absorption in 24 Hr (D570), %	Burning Rate (D635), ipm	Mold Shrinkage, in./in.
0.92	D45-52[c]	—	—	9-11	0.19	<0.01	1.0	0.01-0.05
0.93	D45-65[c]	—	—	8-16	0.19	<0.01	1.0	0.02-0.05
1.2	R118	11-13	11	3.9	0.11	0.3	Self-exting	0.005-0.007
1.35	R100-110	—	5-9[d]	5.6-7.8	0.09-0.12	0.07-0.2	Self-exting	0.001-0.006
1.06	M30-65	NB	4-9	4.7-9.9	0.02-0.10	—	0.06-1.0	0.005-0.009
1.2	R20-120	3.9-9.3[d]	7-22	6-9	0.10-0.19	1.2-2.8	1.0-1.5	0.002-0.007
1.05	R85-100	6.8-8	—	4.7-5.6	0.08-0.12	0.3	1.3	0.001-0.010
1.13	R70-90	4-6	10-35	5.5-11	0.092-0.167	0.8-2.0	0.5-1.5	0.005-0.009
1.13	R80-120	4-10	10-35	5.5-11	0.092-0.167	1.2-2.0	0.5-1.5	0.005-0.009
1.3	R49-103	2.7-7.1[d]	13-20	4.4-9.0	0.10-0.19	2.3-6.5	[e]	0.001-0.007
1.2	R47-95	2.5-5.2[d]	7.5-22	6-9	0.10-0.19	0.9-1.3	0.5-1.5	0.001-0.006
0.95	D63-70[c]	—	—	7-11	0.24	<0.01	1.0	0.02-0.05
1.2	R79-114	4-8	7.5-22	6-9	0.10-0.19	1.3-1.8	0.5-1.5	0.001-0.009
1.3	M91-M95	16	13-15.5	1.8-1.9	—	—	—	0.001-0.005
1.3	R68-115	3.6-8.4[d]	15-25	4.4-9.0	0.10-0.19	1.9-4.0	0.5-2.0[e]	0.001-0.008
2.2	J75-J95	NB	—	5.5	0.034	0.00	Non-inflammable	—
2.1	R112	NB	—	3.88	0.035-0.036	0.00	Non-inflammable	0.005-0.010
1.33	M96-M100	20-22	16	1.6-2.1	1.5-1.7	0.7-1.4	Self-exting	0.0005-0.004
1.06	M30-55	NB	—	3.6-4.7	0.02-0.07	0.04-0.08	1-2	0.002-0.008
1.05	R85-118	7.5-11	—	4.7	0.08-0.12	0.2	1.3	0.001-0.010
1.3	R101-123	5.8-10[d]	19-36	4.4-9.0	0.10-0.19	1.6-3.8	0.5-2.0[e]	0.001-0.009
1.14	R108-118	NB	—	4.8-5.5	0.10-0.14	1.5-2.3	Self-exting	0.010-0.015
1.12	L58-59	9-13	6.3-14	3.9-5.0	0.097-0.12	0.2-0.4	[f]	0.004-0.008
1.4	R120 (M94)	14.1	5.2	4.5	0.13	0.41	1.1	0.01-0.04
0.90	R85-95	8.1	8.5-10	6.2	0.08	<0.01	—	0.015-0.030

[f]Specific values not available; material burns "slowly."
[g]Based on anticipated commercial price of $1.10-$1.50 per lb; present semicommercial price is 11¢ per cu. in.—between those of nylon-glass (15) and TFE (16).
[h]Type I and II cost the same per lb; higher density makes type III slightly higher in cost on a volume basis.

Significant properties: a detailed comparison

Table 1 lists two types of data:

1. Qualitative comparisons of mechanical and electrical properties, and cost, with the lowest figures indicating the most desirable properties. The qualitative ratings are based on property ranges shown in Fig 1-8 and costs shown in Fig 9. Note that costs are given on a ¢ per volume basis.

2. Tabulation of those mechanical and physical properties not given in the bar charts on the following pages.

In using the quantitative data, remember that these values should

***Nylon** is used for electric can opener housing made by Supreme Products. Requirements include strength, rigidity, light weight, surface hardness and gloss, and colorability.*

Spencer Chemical Co.

not be used for design purposes, only for screening. Values are given in ranges. Actual values obtainable will depend on the specific grade of the material, the method of molding or fabrication, and the design of the part.

Toughness and strength

"Toughness" is a subjective term: it is more difficult to define than impact resistance. Toughness is affected by a combination of properties. It is dependent for the most part on the material's impact strength, flexibility (elastic modulus), strength, ductility and damping ability. Unfortunately, the degree to which each of these properties contributes to toughness is not known. Also these properties are sensitive to the rate

Impact Tests: Their Advantages and Limitations

Impact testing is such a controversial and complex subject that a full discussion of it is impossible here. However, a brief description of the tests and some of the problems associated with them may be helpful.

How good are impact tests?

A complete knowledge of the engineering aspects of impact service would enable the engineer to follow a formalized approach in materials selection: 1) study the design of an impact resistant part, 2) assign numerical values to stresses, strains and strain rates, and 3) select a material adequate for the proposed service.

Unfortunately, not only do we lack a sufficiently complete catalog of material properties, but the art of stress analysis is not far enough advanced to permit a complete description of the time-dependent stress and strain functions for a complex-shaped part which must withstand impact loading. Consequently simple tests must be used to establish rankings of materials consistent with rankings established by experience in impact service.

No standard impact test can duplicate a variety of service conditions. The criteria of a good standard test are that it 1) provide a closely reproducible method by which various materials can be compared, and 2) can be carried out in such a way as to simulate closely the type and rate of impact loading anticipated in service. Ideally, such a test would also measure how much energy a material can absorb *before* failure.

The three most commonly used tests for determining impact resistance of thermoplastics are the notched Izod (which uses a cantilever beam; the Charpy, similar to the Izod, uses a simple beam), tensile impact and falling ball or dart. The notched Izod is by far the most universally used. All of these tests are difficult to reproduce accurately. Of the three, the falling ball or dart is probably the test that most closely approaches the type of shock loading common in actual service.

Izod impact test (D256)

The test specimen, usually injection molded, is notched. The notch includes a 45-deg angle and has an 0.010-in. radius at the base. The specimen is clamped in the machine just below the notch and broken by a simple pendulum in a single blow. The energy remaining in the pendulum after breaking the specimen is determined from the follow-through. The difference between this energy and the initial potential energy is the impact strength, in ft-lb per in. of notch, the dimension being taken along the length of the notch.

Advantages of the Izod test: 1) it gives a single index number, 2) testing is quick and economical, and 3) equipment is easily standardized and inexpensive.

Disadvantages of the Izod test: 1) reproducibility is difficult because of difficulty in accurately reproducing test specimens; 2) the stress configuration caused by the notching is complex, and results may often be more indicative of notch sensitivity than of the ability of a material to withstand shock loading; 3) since the effective speed of testing is governed by the notch radius, and most data are given for 0.010-in. radius specimens, impact strengths reported are usually for only one rate of loading; 4) the test cannot be used for flexible materials such as low density polyethylenes, as they do not break in the test; and 5) test results are highly sensitive to orientation within the specimen.

Tensile impact test

This is a nonstandard test developed originally for the more flexible materials such as polyethylenes. A dog-bone specimen is used in a modified Izod testing machine. One end of the specimen is clamped in a vise, the other is held by a fixture, which is struck by the falling pendulum. The resulting fracture is due to pure tensile stress.

Advantages of the tensile impact test: 1) it provides one index value; 2) it is easy and economical to carry out; 3) pure tensile loading is easier to interpret and analyze, permitting isolation of special effects such as notch sensitivity; 4) values for typical plastics range from about 40 to 2000 ft-lb per cu in. (as compared with a range of about 0.1 to 10 or 15 ft-lb per in. notch for the notched Izod test), the wider range providing closer comparative evaluations; 5) there are fewer restrictions on size and shape of test specimen and on type of material; and 6) proponents of the test claim that "rankings" of materials based on the test correlate well with rankings of materials in actual service.

The primary shortcoming of the test is that it gives values for only one rate of loading, and thus does not indicate the effect of altering rates on rate-sensitive materials.

Falling ball or dart

This is a nonstandard test used

at which load is applied. Commonly reported property values have usually been determined only at one test speed. At a different test speed values may differ substantially.

The Izod impact strength test by various laboratories in an attempt to more closely simulate the type of impact loading to be encountered in service. It usually involves the use of a compression (or in some cases an injection) molded flat plate specimen, on which is dropped a ball or dart of a selected weight. Balls of increasing weight are dropped from a predetermined height until the specimen breaks. The greatest weight at which either no specimens break, or at which a predetermined proportion (e.g., 50%) of specimens do not break, is selected as the impact strength of the material.

Advantages of the test method: 1) specimens break in their weakest directions, irrespective of orientation; 2) the test measures the amount of energy the material is capable of absorbing without fracture; and 3) the test is economical to carry out.

Disadvantages: 1) the test is most useful for the more rigid materials; 2) reproducibility is somewhat uncertain; and 3) a large number of samples is required.

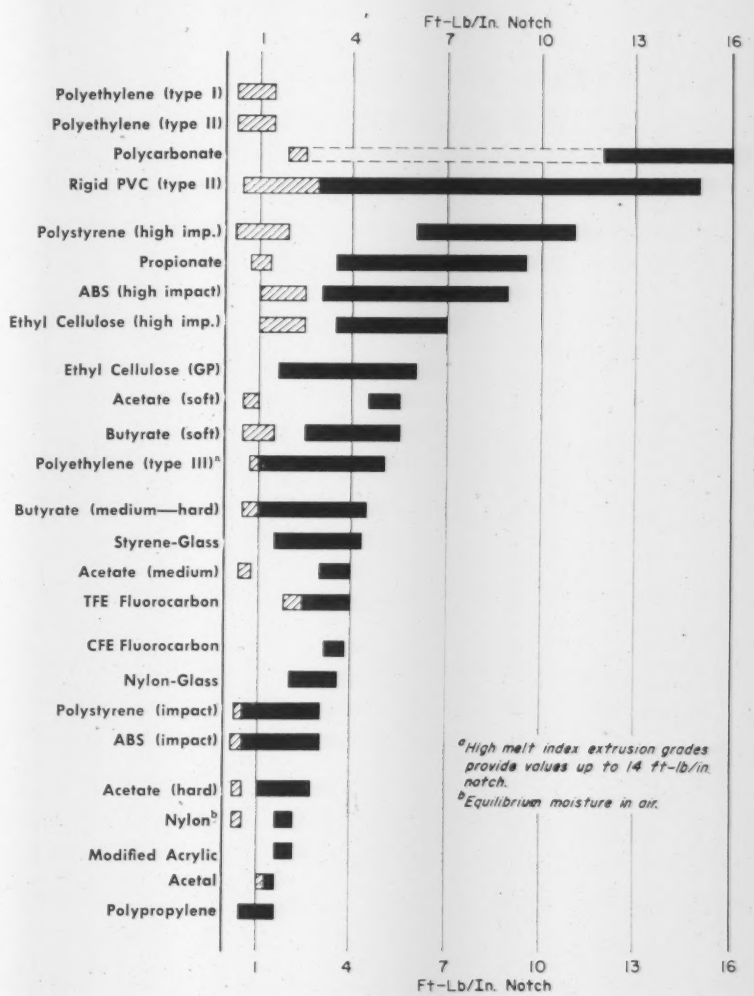
Simulated service tests

Probably the best method of evaluating materials is to use several different types of impact test results for initial screening, followed by a simulated service test.

No matter how many impact tests are developed, none can replace the simulated service test. In addition to reproducing the type of loading to be encountered in service, simulated service tests on the actual part show the effects of design and fabrication variables, such as weld lines and orientation and internal stresses —effects impossible to determine by standard tests.

Marbon Chemical Co.

ABS resin *was chosen for North Wind auto-home air cooler. Strong and rigid, it weighs 17 lb less than previous metal case. Also, it is rustproof and available in attractive pastel colors.*



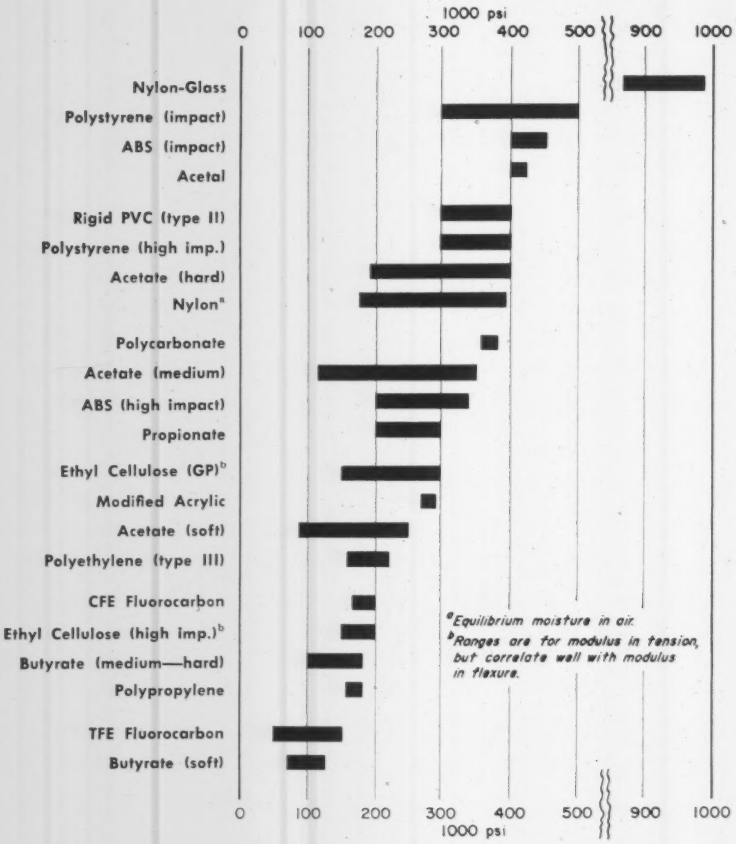
1 Notched Izod impact strength *(D256) at room temperature. Shaded bars indicate range of values at –40 F. Note that even though Table 1 shows general purpose ethyl cellulose as superior to acetate (soft), range of values is such that certain grades of ethyl cellulose have lower values than acetate.*

Eastman Chemical Products, Inc.

Cellulose acetate *was chosen for toy cars made by Scale Model Products. These tough toys needed excellent moldability, smooth glossy finish, scratch resistance, and wide range of colors.*

Dow Chemical Co.

Ethyl cellulose *is used for football helmets. Low breakage of these tough, rigid helmets has resulted in almost exclusive use of ethyl cellulose by Wilson.*



2 Modulus of elasticity in flexure *(D790). Note that chart is broken to include extremely high modulus of nylon-glass.*

is probably the most commonly used single criterion of toughness of plastics. However, test results are relatively meaningless when taken by themselves. Results of the test only indicate the ability of a standard specimen of a given material to resist a specific shock stress applied at one rate of loading. Because they are used so commonly, Izod test results are used here as *one way* of comparing shock resistance of various materials qualitatively.

In Table 1, there are 12 thermoplastics which have notched Izod impact strengths of 5 or more ft-lb per in. notch. These are classified here as the "high impact" materials. The 13 additional materials whose impact strength ranges from about 1.5 to 5 ft-lb per in. notch are classified here as "impact materials." Fig 1 to 4 compare the typical ranges of impact strength, flexural modulus of

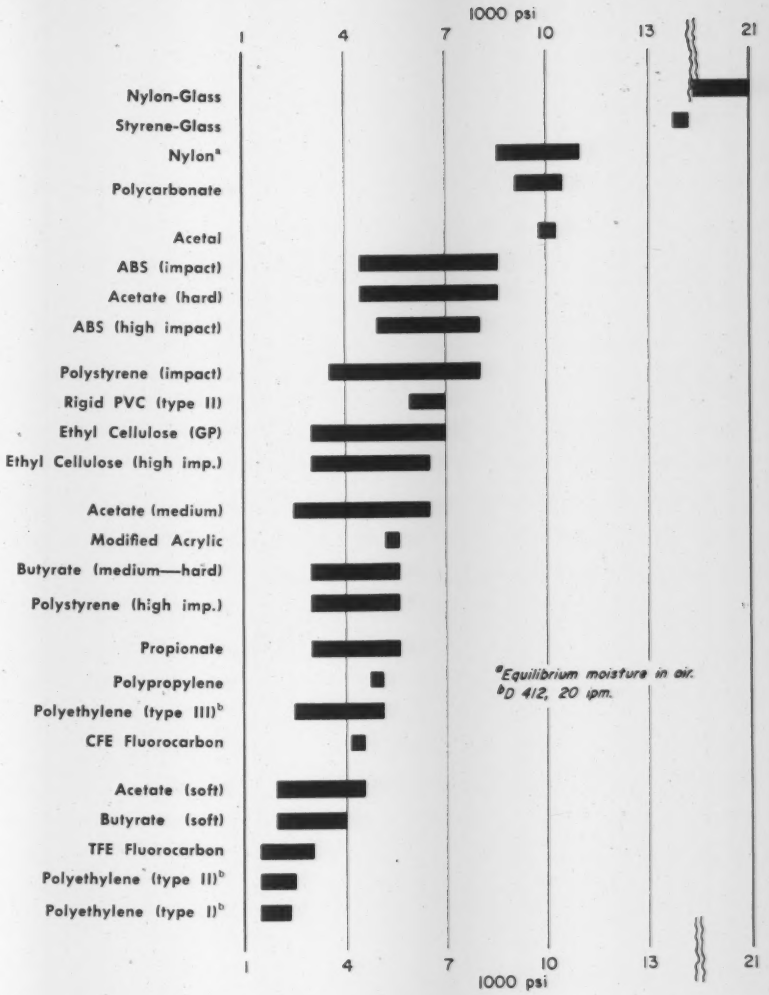
elasticity, ultimate tensile strength and elongation obtainable in all these materials.

The type I and II polyethylenes are not broken in the Izod impact test. They are relatively flexible, low strength materials. Polycarbonate, type II rigid PVC (rubber-modified), high impact polystyrene, cellulose propionate and high impact ABS have an excellent balance of rigidity, strength and ductility at room temperature.

Of course, such qualitative comparative ratings can be misleading. For example, in the case of high impact polystyrene, Fig 1 and 2 show the range of impact strength and modulus obtainable to be typically 6 to 11 ft-lb per in. notch, and 300,000 to 500,000 psi respectively. In general, as modulus increases, impact strength decreases. Consequently in a polystyrene of maximum impact strength of about 11 ft-lb per in. notch, elastic modulus may well be about 300,000 psi or even lower.

Ethyl cellulose, "soft" grades of cellulose acetate and cellulose acetate butyrate, and type III polyethylene also have excellent Izod impact strengths. Their elastic moduli are only moderate.

The danger in using the impact test as the sole indicator of toughness is clearly shown by the 13 materials listed in Table 1 as having Izod impact strengths below



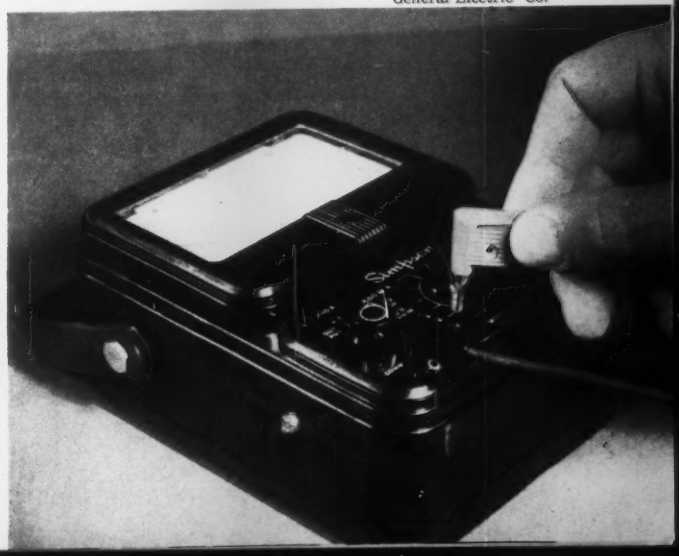
3 Ultimate tensile strength *(D638). Note that values for polyethylenes were obtained at high loading rate of 20 ipm. Chart is broken to include high strength of nylon-glass.*

***Type III polyethylene** is safety hat material. Rigid helmet meets Federal Spec GGG-H-142b for construction workers, and Edison Electric Inst. specification for electrical workers.*

Phillips Chemical Co.

***Polycarbonate** is used for electric connector made by Simpson Electric Co. In addition to high impact, material must have good insulating properties, and good color and gloss.*

General Electric Co.



Selecting a Forming Method

There are four major methods of producing parts in these impact thermoplastics: injection or compression molding, extrusion, thermoforming of sheet, and machining from stock. Other more specialized methods, such as blow molding, require special considerations not discussed here.

In many cases the most economical fabrication or forming method is obvious from the design of the part, e.g., a long gasket of intricate cross section would obviously be extruded. In other cases, cost considerations may require a careful analysis of the part before deciding on the proper production method. Such considerations may involve type of material, production volume, or special design considerations. Both materials suppliers and custom molders can be of help in selecting the optimum method.

A point to keep in mind is that the method of fabrication affects properties of the part. For example, properties of sheet will differ, to varying degrees, from those of the same material as molded. Also, properties of an area of a thermoformed sheet which has been oriented by stretching over the corner of a mold will differ from those in other areas of the sheet. In molded parts, properties of specific areas of the molding can be strongly affected by such factors as orientation resulting from flow, weld lines, parting lines, etc. Consequently, in the early design stages, the custom molder should be consulted to determine the optimum method of molding the part in the material you have selected.

Injection molding

All impact thermoplastics except TFE fluorocarbon can be injection molded. (TFE requires a compacting and sintering operation similar to powder metallurgy techniques. The relatively new extrusion grade, FEP fluorocarbon or Teflon X100, holds promise of being injection moldable.)

Briefly, injection molding is a high production method of producing a large volume of parts ranging from very simple to highly intricate shapes. Since injection molds are relatively expensive, the process usually requires a relatively large production volume to be highly economical.

Compression molding

Though more commonly used with thermosetting materials, compression molding can also be used for thermoplastics where the configuration is such as to make injection molding unfeasible. For example, high quality, rigid vinyl phonograph records are presently produced by compression molding.

Extrusion

All impact thermoplastics can be extruded. The extrusion process offers a relatively rapid method of producing long, continuous shapes with profiles ranging from simple sheet, pipe or tube to highly complex cross sections.

Also, short parts with intricate cross sections can often be economically produced by continuously extruding the proper profile and cutting to length.

Sheet forming

All impact thermoplastics except acetal, ethyl cellulose and

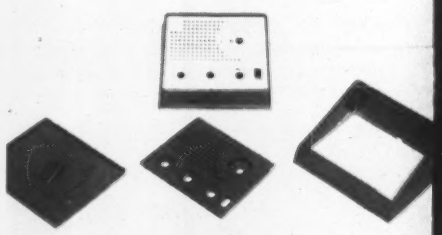
5 ft-lb per in. notch. For example, nylon (1.5-2.0 ft-lb per in. notch) is well known as a "tough" material. Its toughness would seem to be derived from its combination of high tensile strength (the highest of the unreinforced impact thermoplastics), good ductility (as measured by elongation), and a relatively high elastic modulus. Acetal is quite similar to nylon in Izod impact strength, elastic modulus and tensile strength, but has a much lower elongation.

Effects of heat and cold

In general, heat usually softens thermoplastics, increasing impact strength and lowering elastic modulus. Cold embrittles thermoplastics to differing degrees.

Fig 5 compares ASTM D648 heat distortion temperatures for impact thermoplastics under both the 66 and 264-psi stress conditions. (Bear in mind that heat distortion temperature is merely the temperature at which a standard specimen undergoes a specified deflection under a given load, i.e., either 66 or 264 psi.) Table 1 rates the materials qualitatively as to heat resistance under stress.

The differences in the ranking of materials under 66 and 264-psi stress indicate one of the problems in using heat distortion values to describe the stressed heat resistance of a material. For example, nylon has the second highest heat distortion point of any of the materials under 66 psi stress. Under 264 psi stress it ranks ninth below nylon-glass, polycar-



aaRBee Plastics

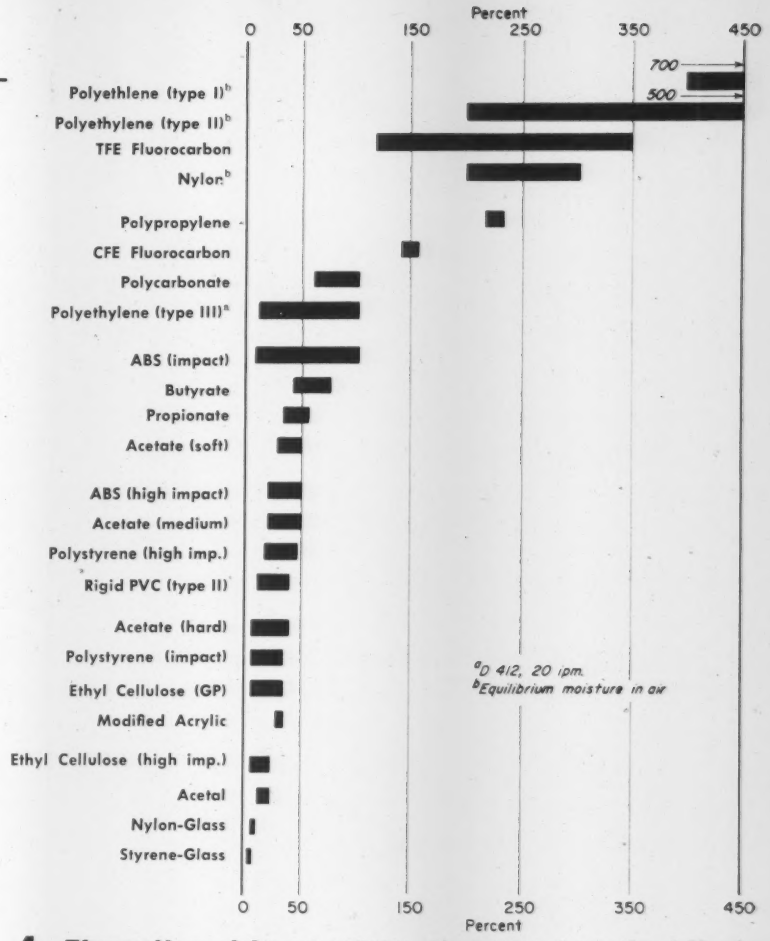
Impact polystyrene *is used for housing of Packard-Bell remote control unit. It has to withstand dropping on solid floor from height of 5 ft. Other requirements: dielectric strength of 300 v per mil, a maximum use temperature of 170 F, wide range of colorability with lustrous finish, and low cost.*

polycarbonate are now available as sheet for thermoforming.

Benefits of sheet formed parts: 1) parts may have very thin walls and large areas beyond the limitations of injection or compression moldings; 2) molds and forming equipment are relatively inexpensive, permitting economical short production runs; 3) predecorated sheet materials can be used; and 4) recent equipment developments permit automatic production at speeds much higher than previously possible.

Machining from stock

Machining a part from stock shapes, such as rod or tube, is primarily used for producing parts of high dimensional accuracy and/or where a small number of parts is needed. All the impact thermoplastics can be machined on conventional hand or automatic screw machines or other machining devices. In general, since thermoplastics soften on heating, and have poor thermal conductivity and high thermal expansivity, the buildup of frictional heat must be carefully avoided.



4 Elongation at break *(D638). Elongations of type I and II polyethylenes range as high as 700 and 500%, respectively.*

High impact polystyrene *was choice for cube steak tenderizer made by Needham Mfg. Co. In addition to low cost, material provides maximum toughness, good colorability, and meets sanitation and other requirements.*

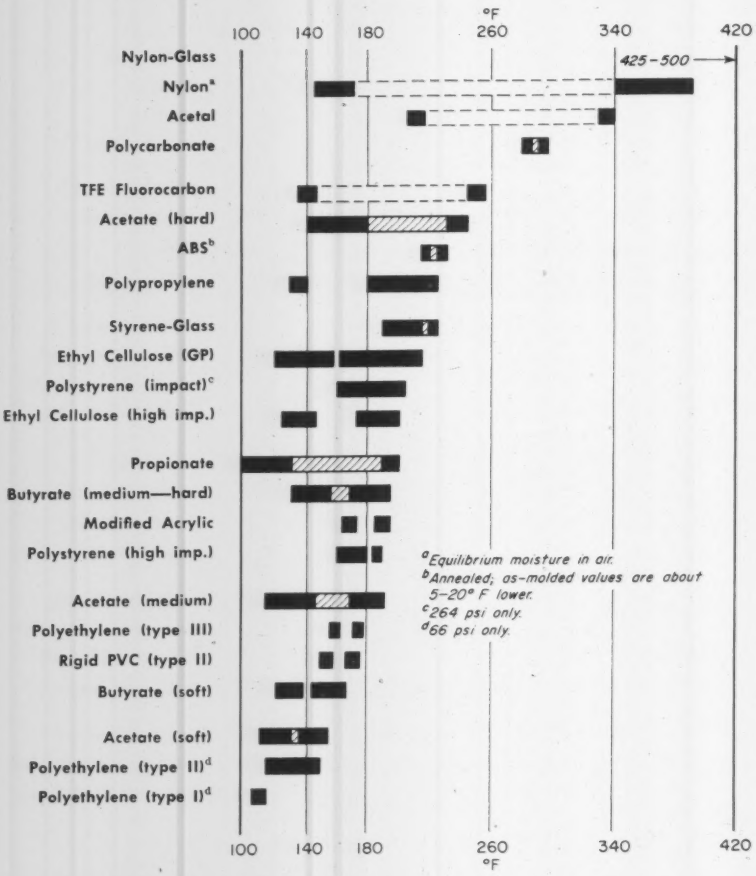
Dow Chemical Co.

Amos Molded Plastics

Impact polystyrene *was chosen for hobby horse body. This toy must withstand flexural, tensile and impact loading. It must also be cementable, highly colorable, and provide good adherence for paints. Material was selected after simulated service test.*

Dow Chemical Co.

High impact ethyl cellulose *is used for auto headlight aimer made by Hopkins Mfg. Corp. Requirements call for low temperature impact strength (SAE drop test of 40 in. at −20 F) plus good dimensional stability and light weight.*



5 Heat distortion temperature *(D648). Higher values are for 66 psi stress, lower values for 264 psi stress. Degree of overlap is indicated by shaded portions of bars.*

bonate, ABS, hard acetate, polystyrene-glass, acetal, cellulose propionate, and polystyrene.

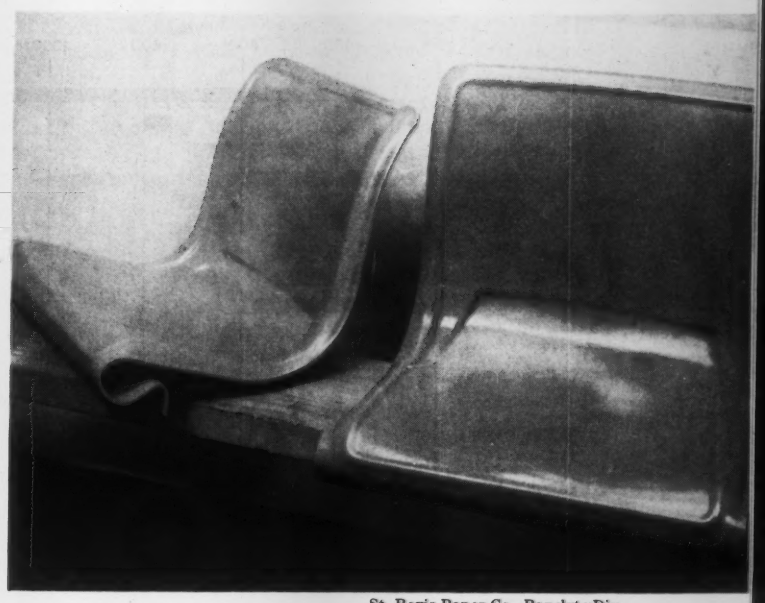
Unstressed, of course, TFE fluorocarbon has the highest heat resistance of any of these materials (it withstands continuous temperatures of over 600 F); however, its flexural modulus is only about 6000 psi at 550 F.

Since thermoplastic materials soften gradually with increasing temperatures, the heat distortion data and comparisons shown here should be used only for initial screening and for general comparisons. When selecting a thermoplastic for a part that will be exposed to heat, the specific stresses, the design of the part, and other environmental conditions must be carefully considered. Only then can the proper grade and formulation be selected.

The crosshatched bars in Fig 1 indicate available data on notched Izod impact strengths at −40 F. As can be seen, rigid PVC, high impact grades of ABS materials, ethyl cellulose, and TFE fluorocarbon have the highest notched Izod values at this low tempera-

Eastman Chemical Products, Inc.

***Butyrate** is popular for outdoor signs. Tough and weather resistant, it also offers the designer a choice of many translucent colors.*



St. Regis Paper Co., Panelyte Div.

***ABS** sheet was formed to make this sport seat. Primary requirements were resistance to outdoor weathering, rigidity, toughness, and ability to be produced with an attractive grained surface.*

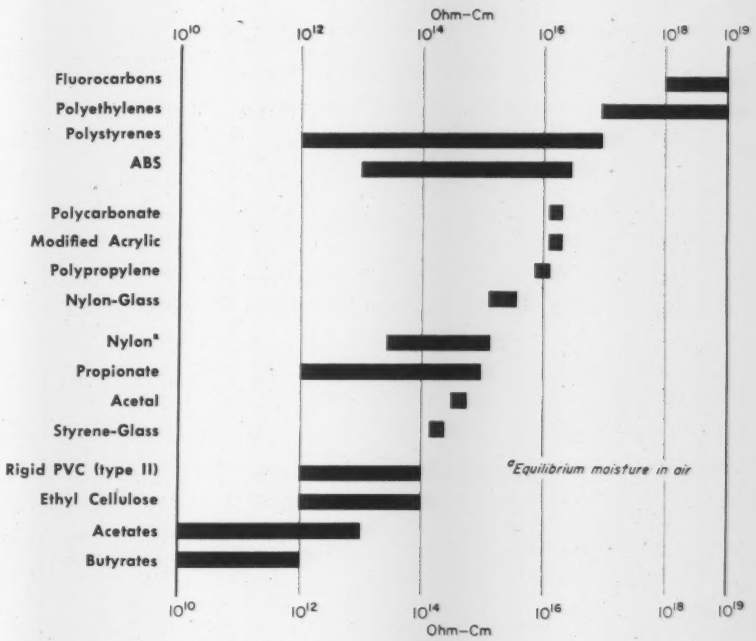
ture. TFE fluorocarbon is the least sensitive to cold.

Dimensional stability

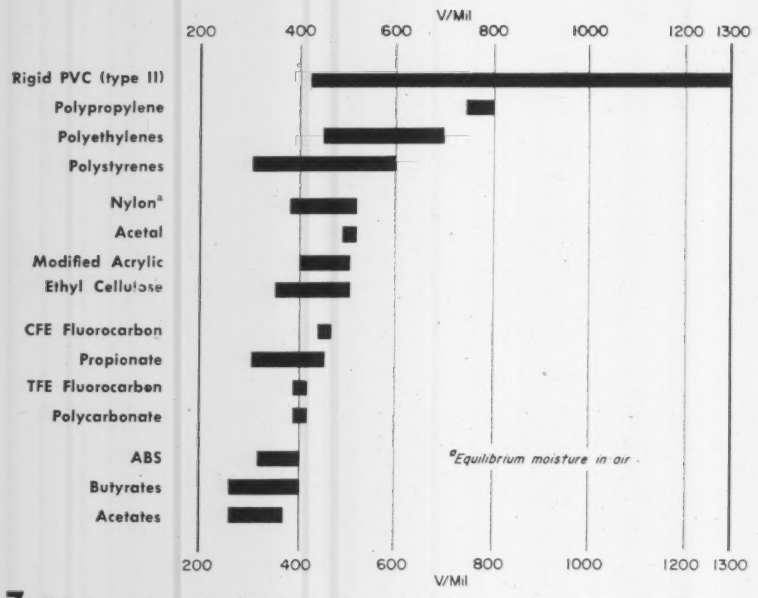
Typical values for moisture absorption of impact thermoplastics are listed in Table 1. Moisture absorption ranges from a low of zero for the fluorocarbons and less than 0.01% (24 hr) for polyethylenes and polypropylene, to a high of about 5-6% for certain acetates. Modified polystyrenes, rigid PVC, the modified acrylic, ABS materials, polycarbonate and acetal all have moisture absorption values of less than 1% in 24 hr.

When using a material with a relatively high moisture absorption for a part where dimensions are critical, change of dimensions with water content must be carefully considered. For example, in a nylon material which has an equilibrium moisture content of 8% submerged in water, as-molded dimensions will increase about 0.025 in. per in. in going to equilibrium in water.

Molded-in stresses, if excessive, can cause substantial warping or distortion of a part. The problem



6 Volume resistivity *(D257). Note wide ranges of resistivity for impact polystyrenes, ABS materials, propionate and acetate. Qualitative comparisons in Table 1 are based on highest resistivity obtainable.*



7 Dielectric strength *(short time, D149). Note extremely wide range of values obtainable in rigid type II PVC.*

is particularly acute with materials such as type III polyethylene and polypropylene which exhibit differential shrinkage. If proper compensation is not made during molding, excessive distortion can result. Molding techniques are now well developed for these materials, and competent molders have little trouble in avoiding such distortion.

Another factor, thermal expansion, must be considered where dimensions are critical. Thermal expansivity of thermoplastics is substantially higher than that of most metals. As shown in Table 1, expansion coefficients range from a low of about 1.8 x 10^{-5} per °F for glass-reinforced polystyrene to a high of 11.8 x 10^{-5} per °F for the polyethylenes. (For comparison, the coefficient is about 0.3 x 10^{-5} per °F for molybdenum; 0.82 x 10^{-5} for carbon steels; and 1.9 x 10^{-5} for zinc and zinc alloys.) Where radical temperature changes are to be encountered in the use of a dimensionally critical part, you must allow for the resulting dimensional changes in the initial design.

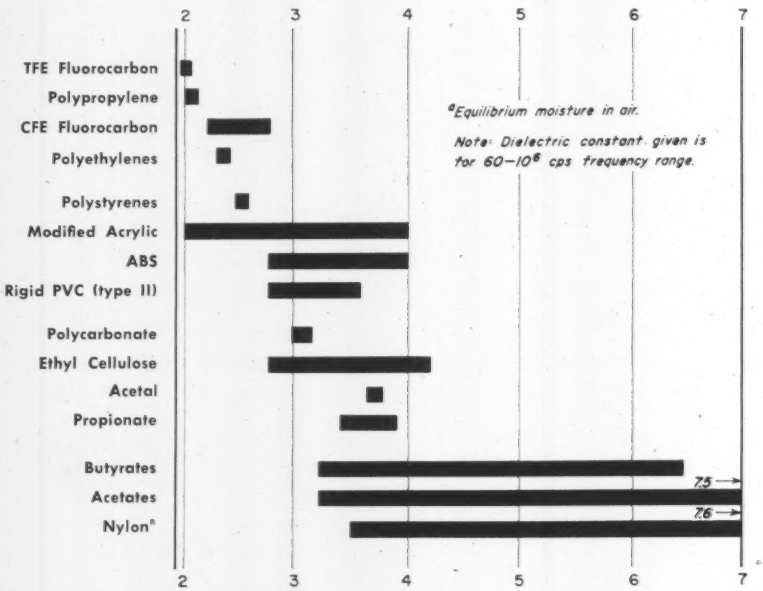
Electrical properties

Space does not permit a complete discussion of electrical insulating properties of the impact thermoplastics. Table 1 gives comparative ratings of the materials in volume resistivity and dielectric strength. Fig 6 and 7 show quantitatively the ranges of these two properties obtainable in specific materials. Fig 8 shows ranges of dielectric constant obtainable over a frequency range of 60 to 10^6 cps.

Polyethylenes, polypropylenes, impact styrenes, ABS materials, fluorocarbons and polycarbonates appear to be among the best insulating materials. They have a balance of good electrical insulating properties, including relatively low losses over the 60-10^6 cps frequency range. Dissipation factor over this frequency range for polyethylenes is 0.0001-0.0005; for polypropylene 0.0002-0.0003; for impact styrenes 0.003-0.02; for polycarbonate 0.004.

Dissipation factor of ABS materials may range from as low as 0.004 to as high as 0.02 (60 cps) depending on type and grade. At 10^6 cps, the ABS range covers a low of 0.010 to 0.026.

Electrical loss in fluorocarbons



8 Dielectric constant *(D150). Ranges cover frequency range of 60-10^6 cps. Low values are desirable for insulation, high values for capacitors.*

is insensitive to frequency. TFE has a dissipation factor of 0.003 over the 60-10^6 cps range; CFE has a loss of 0.015 at 60 cps, 0.010 at 10^6 cps.

Dissipation factors of some of the other more notable electrical materials are: acetal 0.004 (60-10^6 cps); ethyl cellulose 0.005-0.020 (60 cps), 0.010-0.060 (10^6 cps); butyrate 0.01-0.04 (60-10^6 cps); rigid PVC 0.012-0.020 (60 cps), 0.006-0.014 (10^6 cps); and nylon 0.014-0.040 (60 cps), 0.03-0.04 (10^6 cps).

Effects of chemicals

Useful design data on effects of chemicals on plastics are limited. The usefulness of a particular thermoplastic in a chemical environment depends not only on the reagent to which it will be exposed, but on the concentration, the temperature of exposure, and the type of exposure, i.e., total immersion, one-side immersion, exposure to vapors only, or intermittent splash exposure. The only effective way of determining how a material will perform in a particular environment is service testing in that environment.

Of the impact thermoplastics, the fluorocarbons have by far the best all-around chemical resistance; TFE is superior to CFE in this respect. Polypropylene, the polyethylenes and rigid PVC are also highly resistant to attack by most reagents. Polypropylene has proved to have extremely good resistance to environmental stress cracking.

The earlier discussion of materials includes the commonly reported general comments on chemical resistance of the materials. Materials suppliers can provide additional information on effects of specific reagents.

Effects of sunlight and weathering

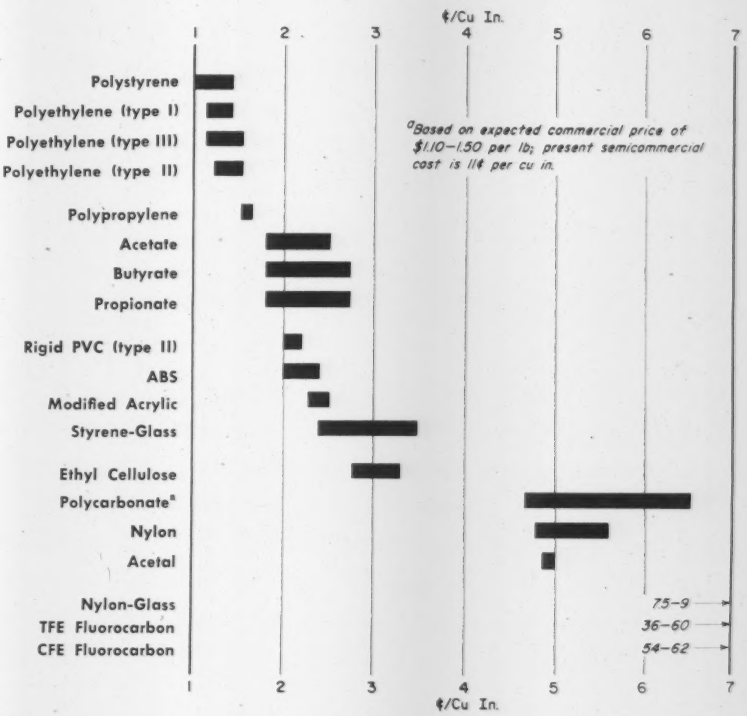
With the exception of the fluorocarbons all impact thermoplastics are affected to a degree by sunshine and weathering. Effects may range from mere discoloration, yellowing, or dulling of a glossy surface to deterioration and complete loss of strength. Data on weatherability are limited and of questionable utility. Outdoor environments differ radically in such deteriorating variables as heat, humidity, ozone concentration, type and quantity of industrial wastes in the atmosphere, wind and dust conditions, amount and severity of sunlight, and amount of rainfall. Where a part is to be used outdoors, specific tests in the service environment should be made.

In brief, the following generalizations can be made: the fluorocarbons are completely inert to weathering. Of the other impact thermoplastics, butyrate, certain grades of ABS materials, polycarbonate, modified acrylic and PVC are the most commonly used outdoors. Both polyethylene and polypropylene in natural colors are attacked by ultraviolet light, but excellent resistance can be provided by compounding with carbon black or certain other dark colored pigments.

A variety of ultraviolet additive materials have been developed for compounding with thermoplastics. Although degradation caused by ultraviolet-initiated oxidation can be reduced in this way, other factors, such as dust abrasion and ozone concentration, preclude the use of many of the materials continuously outdoors. In considering a material for outdoor exposure you should make a careful study to determine the type and extent of degradation permissible for the part to continue to be functional.

Flammability

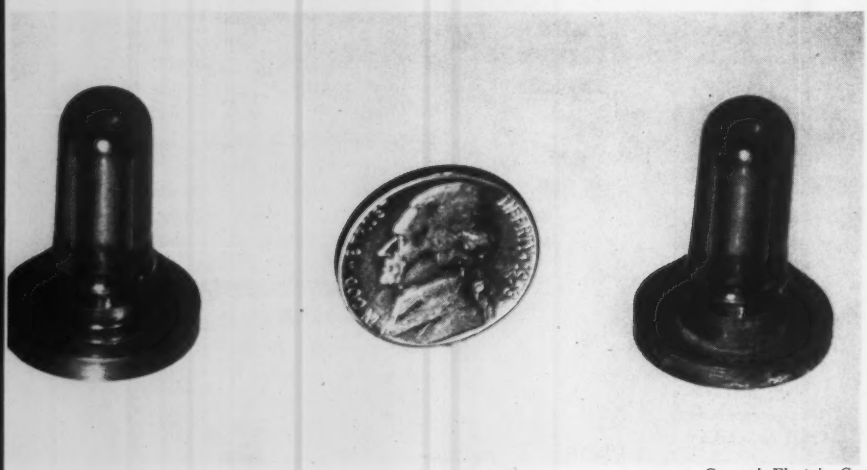
TFE and CFE fluorocarbons are the only completely noninflammable impact thermoplastics. PVC can be ignited with difficulty, but is self-extinguishing when the flame is removed. Polycarbonates and nylons are self-extinguishing, and self-extinguishing grades of acetate are available. Other materials have burning rates as shown in Table 1.



9 Comparative volumetric cost. *Note that materials break down roughly into three divisions: materials under 1.6¢ per cu in., materials ranging from 1.8 to 3.5¢ per cu in., and high cost materials ranging upward from 4.7¢ per cu in.*

B. F. Goodrich Chemical Co.

***Type II rigid PVC** is used for washdown pipe on ships. Need for light weight, toughness, and resistance to weathering and sea water, called for impact PVC in piping used to protect U. S. Navy ships from contamination by radioactive fallout.*



General Electric Co.

***Polycarbonate** was chosen for oil bonnets. Used as a sight glass, bonnets must be transparent, resist lubricating oil, and withstand 1500 psi line pressure without deformation or leakage.*

Optical properties

Of the impact thermoplastics, only acetate, butyrate, ethyl cellulose and polycarbonate are available in transparent form in sections heavier than film. Acetate and butyrate can have 75-95% light transmission, ethyl cellulose up to 90%, and polycarbonate up to 83%. CFE can also be made transparent by proper processing.

All the other thermoplastics are available either translucent or opaque, with virtually unlimited colorability. (TFE fluorocarbon is available only opaque, and can be color-coded.)

Acknowledgments

The author would particularly like to thank R. O. Hill, Eastman Chemical Products, Inc., and B. Nathanson and R. McCarthy, Monsanto Chemical Co., for reviewing the manuscript.

The assistance of personnel and literature of the following companies is also greatly appreciated:

aaRBee Plastic Co.
Amos Molded Plastics, Div. of Amos-Thompson Corp.
AviSun Corp.
B. F. Goodrich Chemical Co.
Bolta Products Div., General Tire & Rubber Co.
Celanese Plastics Co., Div. of Celanese Corp. of America
Chemore Corp.
Dow Chemical Co.
Eastman Chemical Products, Inc.
E. I. du Pont de Nemours & Co., Inc.
Escambia Chemical Corp.
Fiberfil, Inc.
Firestone Plastics Co.
Footwear Div., U. S. Rubber Co.
General Electric Co., Chemical & Metallurgical Div.
Gries Reproducer Corp.
Hercules Powder Co.
Koppers Co., Inc.
K-S-H Plastics, Inc.
Marbon Chemical, Div. of Borg-Warner Corp.
Minnesota Mining & Mfg. Co.
Mobay Chemical Co.
Monsanto Chemical Co., Plastics Div.
Naugatuck Chemical Co., Div. of U. S. Rubber Co.
Phillips Chemical Co.
Rohm & Haas Co.
Spencer Chemical Co.
St. Regis Paper Co., Panelyte Div.
Union Carbide Plastics Co., Div. of Union Carbide Corp.
Westinghouse Appliance Div., Westinghouse Electric Corp.

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first in silicones

Dow Corning

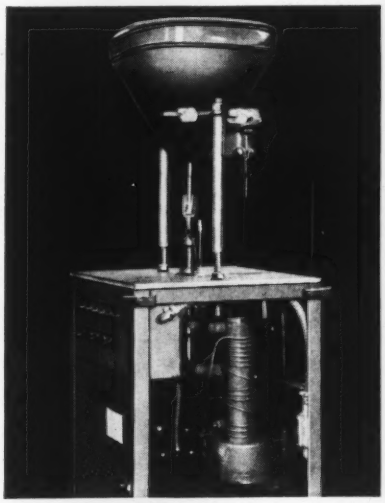
SILICONE NEWS

for design and development engineers • No. 68

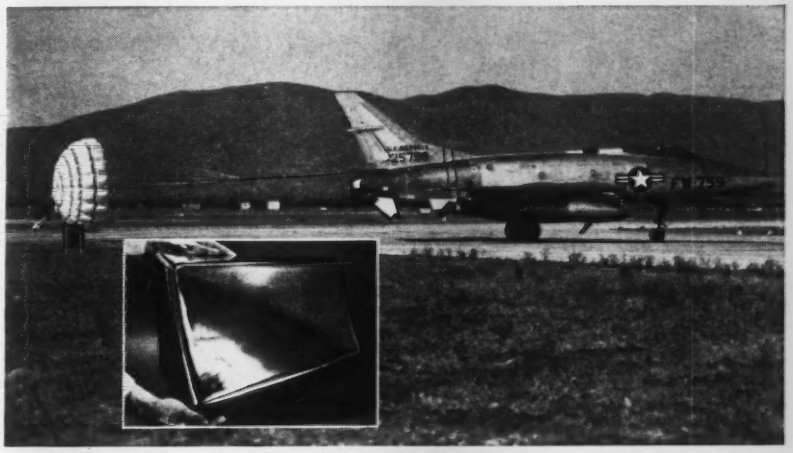
Provide Fine Vacua Quickly, Economically

Engineers in numerous industries credit several design improvements and manufacturing benefits to the use of silicone diffusion pump fluids. Examples include vacuum metallizing of plastics, electron microscopy, vacuum metallurgy and coating of glass, and production of television and cathode ray tubes.

Dow Corning silicone diffusion pump fluids offer a combination of properties that are put to practical advantages in attaining fine vacua. The property of primary importance is greater stability, but silicone fluids also offer such desirable characteristics as rapid recovery and quick pump down, inertness to air and metals, high vacuum, resistance to gamma radiation, and noteworthy economies.



The stability of silicone diffusion pump fluids makes it possible to release pump vacuum without first cooling the boiler. Exposure to air at operating temperature does not cause the fluids to decompose to gums or tars nor lose their vacuum pumping properties. For example, Dow Corning 704 Fluid, tested in a CVC type G-4 pump was unchanged in properties after more than 2,000 cycles of 12 minutes pump operation followed by 3 minutes exposure to the atmosphere at operating temperature. For more information about properties and applications, circle . . . **No. 242**



CONSTRUCT BETTER HEAT BARRIER WITH SILICONE-GLASS LAMINATES

Relatively unaffected by temperatures that destroy many structural materials, silicone-glass laminates helped solve a tricky insulating problem on the F-100 Super Sabre built by North American Aviation, Los Angeles, California.

The nylon drag chute of this jet fighter is stored near the afterburner — and in-flight temperatures of the storage area frequently climb to 450 F and higher. This is far in excess of the 200 F limit of the nylon chute, so North American had to provide some kind of protective case.

Originally made of one laminate of glass cloth and TAC (triallylcyanurate) with inner layer of polyester, with an outer coating of aluminum foil, the walls of the case simply wouldn't stand up in high temperature service. Various other combinations of materials were tried, and finally, a silicone-glass laminate coated with gold was employed as the outer layer.

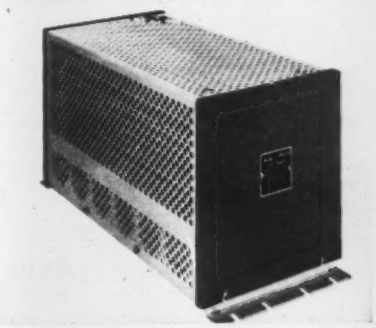
Able to withstand continuous exposure to 750 F and intermittent exposure to temperatures as high as 1200 F, the silicone-glass laminate proved more than a match for the temperatures encountered. It proved easier to work with than any other material, according to the fabricator, Barrier, Inc., Sun Valley, Calif.

Strong and lightweight, silicone-glass laminates retain a better strength-to-weight ratio at high temperatures than many light metals. Silicone-glass laminates are molded to a wide variety of shapes as structural and electrical insulating components for many different applications. **No. 241**

Trim Off Excess 'Fat'

Insulating electrical equipment with silicones not only reduces equipment size and weight, but it frequently also cuts the cost of the overall unit. Here's a typical example from Sorenson & Company, builder of scientific apparatus for industry.

Sorenson builds an a-c voltage regulator rated at 2 kva that's no larger than an overnite travel bag and weighs only 87 pounds. Comparable units on the market are half again as large and *(Cont. Pg. 2)*



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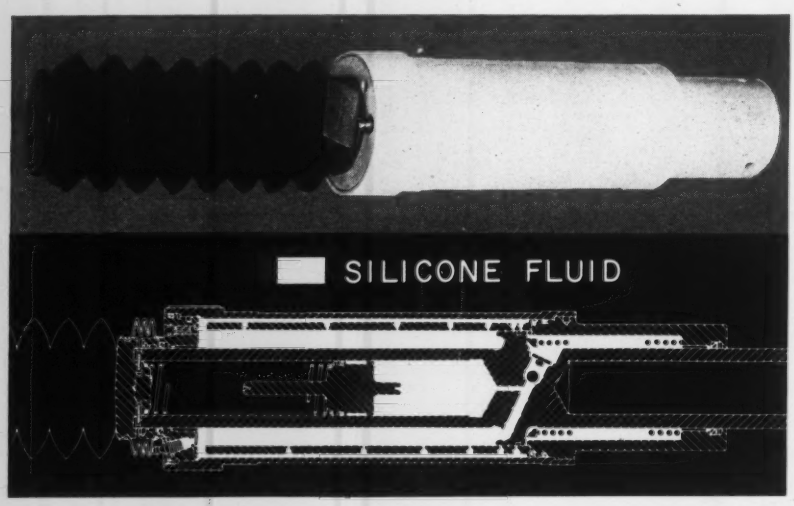

DAMPING MADE EASIER

Engineers are no longer restricted by limitations imposed by organic damping fluids. Silicone fluids readily exceed most thermal requirements. This is nicely illustrated in the new Radar Antenna Buffers built by Houdaille Industries, Buffalo, New York.

Installed at the limits of antenna travel, these buffers are designed to prevent damage to the assembly caused by over-travel. The units dissipate the energy of extreme shock loads by hydraulic damping. Filled with heat-stable Dow Corning silicone fluid, the buffers absorb shock loads of up to 125,000 pounds in less than 9 inches of travel! The silicone fluid assures reliable operation down to —65 F, much lower temperatures than possible with the best organic fluids. And performance characteristics are not altered appreciably by temperature changes.

Engineers at Houdaille found that Dow Corning silicone fluid more than met all of their service requirements. Exceptionally resistant to cold, oxidation and breakdown under shear, the silicone fluid absorbs shock loads and minimizes the effect of temperature on performance to less than 1% per 100 Fahrenheit degrees. Another plus: noncorrosive, nonsludging silicone fluid assures minimum maintenance and exceptionally long service life.

Houdaille Buffers are being used on installations of the Air Force's Early Warning System for ICBM's. The buffers can also be engineered to cushion the impact of air-dropped equipment and for missile handling equipment. *No. 243*

INSULATION *(Continued)*

weigh up to 200 pounds. Why the difference?

The answer is the extra thermal stability obtained by using insulating materials made with Dow Corning Silicones. Sorenson engineers estimate they've lopped off 35% of the bulk and 55% of the weight by insulating the voltage regulator with silicones instead of Class A or B materials. The result is a much handier unit with a substantial increase in sales appeal.

But that's not all. By insulating the regulators with Dow Corning Silicones, Sorenson found they actually reduced the overall cost of the insulation and the assembled unit. In addition, the silicone insulation assures reliable power even when the voltage regulator is exposed to high ambients, moisture and corrosive atmospheres. *No. 244*

new literature and technical data on silicones

ESPECIALLY FOR TRANSISTORS—Dow Corning 5 Compound is a grease-like silicone dielectric used as a potting material for transistors. It has a wide range of serviceability (–100 F to over 400 F). Among its other outstanding advantages are purity, excellent dielectric properties, rapid heat conductivity, good heat stability, water repellency, and ease of application. A pamphlet contains the typical properties and information a designer wants to know. *No. 245*

KEEP 'EM COOL WITH SILICONE FLUIDS—Designers of electronic assemblies are using silicone fluids as dielectric coolants to solve problems created by extreme environmental conditions and miniaturization in control circuitry of aircraft, missiles, submarines, and industrial communication systems. A data sheet contains complete information for designers. . . . . *No. 246*

THE FULL STORY OF SILASTIC RTV

A new sound and color film tells the story of the Dow Corning fluid silicone rubber that vulcanizes at room temperature and requires no heat for curing. You can see how Silastic® RTV effectively resists weathering, moisture, oxidation, shock and vibration. The film aptly demonstrates how prototype molds and parts can be made quickly with this ready-to-use silicone rubber. Learn how you can arrange for a showing of this film in your own plant by writing for . . . . . *No. 247*

LONGER-LASTING PROTECTIVE COATINGS—An article reprinted from a recent issue of ***Products Finishing*** explains why the gloss retention and chalk resistance of silicone surface coatings are excellent . . . even when plant equipment is exposed to wide ranges of ambient temperatures over a period of years. By specifying silicone paints, enamels, and other surface finishes, you will decrease future maintenance costs, increase intervals between refinishings, and improve appearance. . . . . *No. 248*

Dow Corning Corporation, Dept. 7023, Midland, Michigan

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FILE FACTS

Rhodium Electroplates

Major Properties and Uses

The properties of rhodium electroplates depend on the type of plating bath used. The following discussion of properties generally applies to deposits produced by the optimum plating bath for a specific application. Detailed property data are given in the accompanying table.

Decorative and reflective properties. Rhodium electroplates are principally distinguished for their hard, brilliant white, non-tarnishable, highly reflective surfaces, and the fact that they can be applied to almost any base metal. Because of these properties, electroplates are ideally suited as functional finishes and as decorative finishes for costume jewelry, accessories, eyeglass frames, insignia and musical instruments. The desirable physical and optical characteristics of rhodium electroplates are also utilized in reflectors for motion picture projectors and various laboratory devices. In these applications electroplates offer very high reflectivity over the visual and infrared range, in addition to resisting corrosive atmospheres and mechanical damage.

Electrical properties. Rhodium electroplates are particularly useful in electrical and electronic applications. Rhodium plates improve the efficiency of contacts where low electrical resistance, long life, and freedom from oxide and corrosion products are required. Also, rhodium plates provide low noise level for moving contacts, eliminate oxide rectification, and have low and stable contact resistance even after long periods of inactivity.

Rhodium eletroplates are also used in: 1) relays and tuned lines, where they remain oxide-free and prevent spurious signals and partial rectification; 2) electron tubes, where they suppress secondary emissivity; 3) printed circuits, where they have good adhesion and provide long life and corrosion resistance; and 4) inductance tuners, where they provide low and stable contact resistance.

Corrosion properties. In general, rhodium is not attacked by common acids and alkalis. It is resistant to such acids as aqua regia, nitric, sulfuric (cold), phosphoric, hydrochloric and hydrofluoric. It is also resistant to such gases (at room temperature) as chlorine, bromine, hydrogen sulfide, dry iodine, and hydrocarbons. Rhodium is also inert to marine atmospheres and to practically all industrial atmospheres. In all cases, porosity of the deposit should be considered so that an efficient thickness and type of base metal can be selected.

PHYSICAL AND MECHANICAL PROPERTIES

Density, lb/cu in.	0.45
Melting Point, F	3570
Boiling Point, F	8130
Vickers Hardness (20-gm load)	540-640
Reflectivity, %	80
Specific Heat (50-207 F), Btu/lb/°F	0.1062
Thermal Cond (63 F), Btu/hr/sq ft/°F/ft	50.8
Coef of Ther Exp, per °F	4.55×10^{-6}
Electrical Resistivity (32 F), microhm-cm	4.69
Temp Coef of Resistance (32-212 F), per °F	0.00242
Magnetic Susceptibility (64 F), per gauss	1.14×10^{-6}
Attenuation (copper = 1)	1.53

Thickness of Deposits

Rhodium electroplates are normally used in thicknesses from 0.001 to 0.005 mil for decorative applications. Depending on service requirements, coatings for electrical contacts range in thickness from 0.005 to 0.01 mil. Plates for printed circuits and wave guides are generally 0.005 mil thick. Following are some typical thickness recommendations (in thousandths of a mil):

Decorative finish	1-5
Reflectors	10-15
Tarnish protection	5-10
Average corrosion protection	10 (min)
Severe corrosion protection	100+
Light duty electrical contacts	5-20
Heavy duty electrical contacts	10+
Severe wear electrical contacts	20+
Infrequently used contacts	20+

Plating Baths

Rhodium electroplates can be deposited from a variety of plating baths. These baths can be classified into three main types: 1) phosphate, 2) sulfate, and 3) proprietary. In general, the phosphate baths are recommended for decorative applications, whereas the sulfate baths can be formulated for general purpose use as well as for heavy duty applications. Both the phosphate and sulfate baths produce deposits which are in tensile stress. The third type of bath (proprietary) produces compressively stressed deposits which are claimed to have superior adhesion and density. This type of bath is generally recommended for heavy duty industrial uses rather than purely decorative applications.

Basis Metal Pretreatment

Because of their thinness, rhodium electroplates cannot cover surface imperfections and flaws. Therefore, base metals must be given a perfect finish to remove surface imperfections and prevent spurious light reflections.

Pretreatment usually consists of polishing followed by soaking in an ammoniacal soap solution or emulsion cleaner to remove polishing compounds. Brushing and vapor degreasing are also sometimes used after polishing. Surfaces are then rinsed in hot water and treated in an electrocleaner. Electrocleaning is followed by several water rinses, a dip in 10% potassium or sodium cyanide solution, a very thorough water rinse, a final dip in 10% sulfuric acid, and a water rinse prior to plating.

In general, rhodium may be plated directly over copper, nickel, silver, palladium, gold and most alloys of these metals. All other metals should be given a nickel underplate before rhodium plating. Tin alloys should be given a copper flash prior to nickel plating.

The help of Engelhard Industries, Inc. and Sel-Rex Corp. in preparing these data is gratefully acknowledged.

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in the 4th Annual Awards Competition for Best Use of Materials in Product Design

16 CASH AWARDS	FIRST AWARD $500 and plaque	FIVE AWARDS OF MERIT $100 each and certificate	TEN CITATIONS $50 each and certificate

Enter any new product or redesigned product, assembly, subassembly or single part that shows sound, imaginative or progressive use of engineering materials.*

**Engineering materials: metals, nonmetallics, finishes and coatings, and materials forms (such as castings, forgings, moldings, etc.)*

Rules of the Competition: A Brief Summary *(For complete details, see the October issue, pp 109-112).*

1. Materials producers or suppliers are not eligible.

2. The entry must have been designed, redesigned or put into production during the calendar year of 1959.

3. Provide the following information:

a. A detailed description of the product, including photographs, drawings, before-and-after illustrations, etc.

b. A description of the service and/or fabrication requirements that must be met by the product or material(s).

c. A description of the material(s) previously used (if entry is a redesign).

d. A description of the material(s) selected for the entry.

e. An explanation of *how* and *why* the material(s) selected best met the design and service requirements or (if a redesign) resulted in improved performance and/or lower cost. Back up the selection of the material(s) with evidence—facts, data, charts and tables.

4. Entries or portions thereof will not be returned unless requested. Send copies, not originals, of valuable papers.

5. MATERIALS IN DESIGN ENGINEERING reserves the right to publish articles based on winning and non-winning entries. Payment for non-winning articles published will be at usual rates. Judges reserve right to withhold awards at their discretion.

6. All entries must be postmarked not later than *February 1, 1960.*

For description of last year's award winners see May '59 issue, pp 121-144.

TO SEND YOUR ENTRY:

Use a separate blank for each entry; additional entry blanks available on request. Attach entry blank below, or its equivalent, to your entry and mail to:

Awards Editor, Materials in Design Engineering, 430 Park Ave., N. Y. 22, N. Y.

Name _____ Title _____

Name(s) of person(s), group or organization who would receive award _____

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Company _____

Street address _____ City _____ State _____

Name or brief description of product being entered _____

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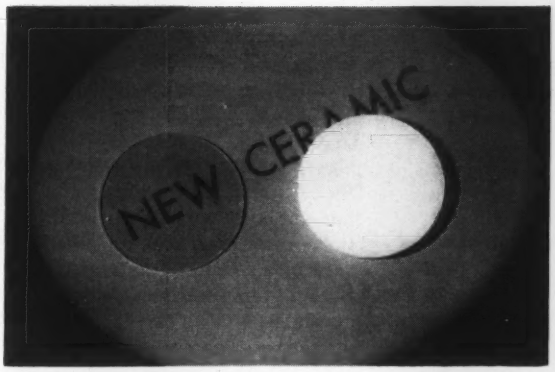
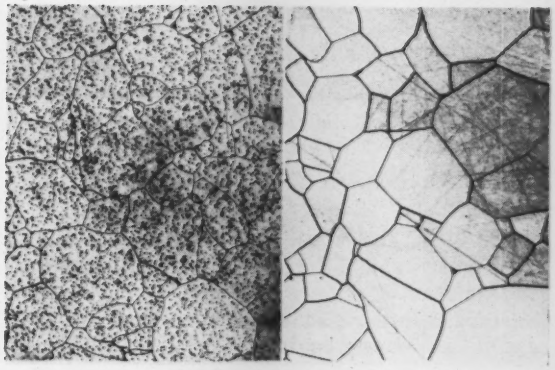
Was design (or redesign) of entry either completed or placed in production during 1959? _____

Does your employer consent to entry under terms of this competition? _____

Edited by
John A. Mock



Clear ceramic *(left) resulted from the removal of all microscopic pores from alumina that make conventional ceramics (right) appear opaque.*



Photomicrographs *(100X) show the difference between conventional ceramic (left) and Lucalox (right). Pores in conventional ceramic scatter light, making the material opaque.*

Alumina Ceramic Is Translucent

It is also tough, heat resistant

■ A polycrystalline alumina ceramic that transmits at least 90% of the light in the visible spectrum has been developed. According to the developer, it is possible to read through a sheet of the ceramic when it is laid flat on a piece of paper. At greater distances it appears translucent, resembling frosted glass.

The new polycrystalline ceramic was developed in the research laboratory of General Electric Co., Schenectady, N. Y. It is called Lucalox.

Material is pore-free

The light transmitting abilities of the material result from the fact that microscopically small pores, or "bubbles," which are normally found in ceramic materials have been entirely removed from aluminum oxide.

The developer does not say how pores are removed. However, GE does say that the translucent ceramic is made by pressing fine grain, high purity aluminum oxide at room temperature, then firing at temperatures that are higher than usual for ceramics.

Potential uses

GE foresees many uses for Lucalox in scientific, military and industrial applications. One use would be high intensity incandescent and discharge lamps, which are now limited by the heat resistance of their transparent envelopes. Fused quartz, which is often used for high temperature lamps, performs satisfactorily at temperatures up to 1800 F, whereas Lucalox is stable at temperatures close to 3600 F.

Another possible application for the material is in the banks of infrared lamps that are used to test the heat resistance of

PROPERTIES OF LUCALOX

PHYSICAL PROPERTIES	
Density, lb/cu in.	1.04
Melting Point, F	3700
Total Light Transmission, %	At least 90
Ther Cond, Btu/hr/sq ft/°F/ft	18.4
Coef of Ther Exp, per °F	4.8×10^{-6}
MECHANICAL PROPERTIES	
Transverse Rupture Str, psi	50,000
Hardness (VPN)	1660-1930
ELECTRICAL PROPERTIES	
Volume Resistivity, ohm-cm	2×10^{12}
Dielectric Strength, v/mil	1700
Dielectric Constant	9.85
Power Factor	0.00003

At 2300 F *bar of Lucalox supports a 50-gm weight, whereas bar of quartz bends under its own weight.*

What's new IN MATERIALS

missile nose cones and other space vehicle equipment. The ceramic may also be used as an electrical insulation and for gem bearings in delicate equipment.

Metal-like structure

The translucent ceramic is said to have the composition of a ceramic, the structure of a metal, and light transmitting ability approaching that of glass.

Lucalox has a metal-like structure in that its crystals are bonded directly to one another, with neither pores nor a glass matrix between them.

Related to sapphire

The new material, still in the developmental stage, is closely related to sapphire and ruby, both of which are single crystal, aluminum oxide materials. However, Lucalox is superior to sapphire and ruby in heat resistance.

According to Dr. Guy Suits, vice president and director of research for GE, the new material has the extremely high temperature characteristics of alumina ceramics, can withstand much higher temperatures than most ceramics now in use, and can be pressed in any shape desired. He says no other material combines translucence with this degree of strength, heat resistance and ease of fabrication.

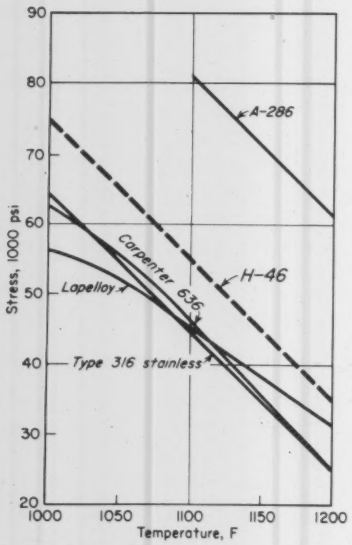


Fig 1—*100-hr stress-rupture strength of H-46 compared with that of four other steels.*

Modified 12% Chromium Steel Is Strong, Ductile at 1200 F

■ A modified 12% chromium steel that is said to have good strength and ductility at temperatures up to 1200 F is now available from Carpenter Steel Co., Reading, Pa. The alloy, developed in England and produced by Carpenter under license, is available in the form of billet, bar, wire, strip and special shapes.

Composition, heat treatment

The new alloy, designated H-46, is described as a fully martensitic steel designed to fill the gap between conventional 12% chromium steels (which have unsatisfactory strengths at temperatures above 1050 F) and the highly alloyed, relatively expensive austenitic steels (such as A-286). The alloy's composition is carefully balanced to produce a fully martensitic structure (see composition table).

Heat treatment consists of hardening 1 hr at 2100 F, air or

COMPOSITION OF H-46 (%)

Carbon	0.15-0.20
Manganese	0.50-0.80
Silicon	0.20-0.60
Chromium	10.0-14.0
Nickel	0.30-0.60
Molybdenum	0.50-0.80
Vanadium	0.20-0.40
Columbium and Tantalum	0.20-0.60
Nitrogen	0.06-0.10

oil quenching, then tempering 2 hr at 1200 F.

Properties

In the fully heat treated condition, H-46 has a minimum V-notch Charpy impact strength of 15 ft-lb. The 100-hr stress-rupture strength of H-46 as compared to that of two other martensitic steels and two austenitic steels is given in Fig 1. As shown, H-46 is superior to all except A-286. The Lapelloy alloy, which has better properties at 1000-1200 F than any of the other well-known martensitic steels, has considerably lower stress - rupture strength than H-46. The new alloy is also said to possess good creep strength (see Fig 2) and a low coefficient of thermal expansion. Room and elevated tensile properties of H-26 are given in Fig 3.

Fabrication

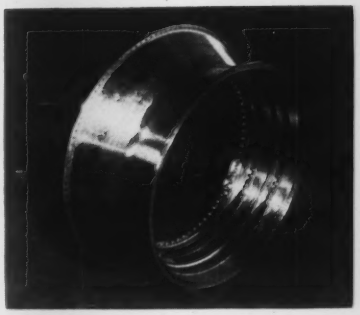
Welding—According to Carpenter, H-46 is easily welded. Fusion welding with inert gas and preheating to 300-400 F are recommended for best results.

Forging—H-46 has good forgeability and can be hot worked between 2150 and 1650 F. A slow cool is recommended.

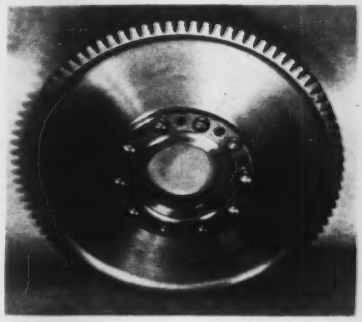
Machining—H-46 is comparable to type 420 stainless and is readily machined in the hardened and tempered conditions.

H-46 parts used in jet aircraft . . .

Welded ring



Turbine wheel



Stator ring

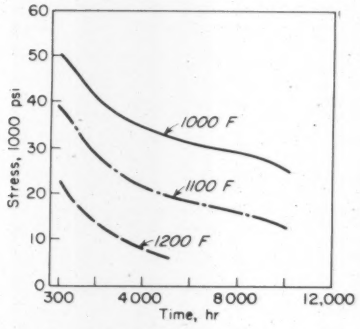


Fig 2—*0.5% creep strength of H-46 at various temperatures.*

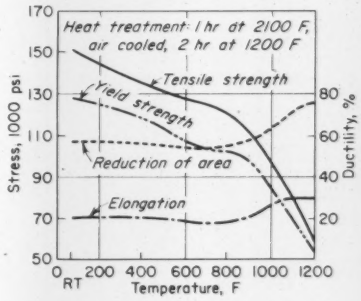


Fig 3—*Room and elevated temperature tensile properties of H-46.*

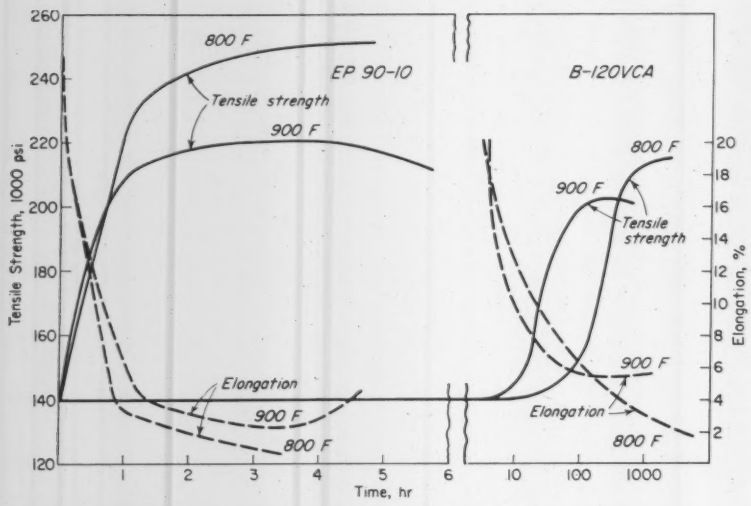
Titanium Alloy Hardens Rapidly at 800 F

■ Two new titanium alloys, which are said to possess outstanding characteristics as a result of the use of electrolytic high purity titanium and chromium, have been developed by Chicago Development Corp. in cooperation with Manganese Chemicals Corp. Both are described as single phase, fully hardenable alloys.

Designated EP 90-10 and EP 20-2, the new alloys are thus far available only in test quantities. Outstanding characteristic of EP 90-10 is extremely rapid hardening for good elevated temperature strength; outstanding characteristic of EP 20-2 is high temperature oxidation resistance.

EP 90-10

This weldable alloy, which is composed of 90% electrolytic high purity titanium and 10% electrolytic high purity chromium, can be softened by quenching and then "fully rehardened in minutes rather than days." The alloy's ability to be hardened rapidly gives it a decided advan-



Effect of aging *on tensile properties of several titanium alloys.*

tage over B-120VCA, the high strength, all-beta titanium alloy developed about a year ago (see M/DE, Sept '58, p 131).

According to the developers, EP 90-10 can be hardened at 800 F to a tensile strength of 220,000 psi in less than an hour. To reach this strength with B-120VCA would require several weeks (see accompanying graph). At 900 F, hardening is more rapid with both alloys; however, 100 hr is still required for the B-120VCA alloy, as compared with only minutes for the EP 90-10 alloy.

Another important advantage is the new alloy's specific gravity (4.71). Although this specific gravity is about the same as that of conventional alloys, it is significantly lower than that of the B-120VCA alloy. Tensile properties of EP 90-10 at various temperatures and conditions are given in the accompanying tables.

According to the developers, the alloy should be ideally suited for pressure vessel applications because the hot rolled material can be welded to provide high strength without elaborate heat treatment. The alloy's hardening characteristics also suggest its use for aircraft parts now made of much denser, and less strong hardenable copper alloys.

ELEVATED TEMPERATURE PROPERTIES OF TITANIUM ALLOYS

Alloy ↓	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong (in 2 in.), %
EP 90-10			
Rm Temp	200	175	6
800 F	150	130	10
1000 F	125	115	12
EP 20-2			
Rm Temp	190	170	6
800 F	160	140	8
1200 F	130	115	10
1800 F	50	30	12

EP 20-2

This alloy, which contains 20% aluminum, 2% high purity vanadium and 78% electrolytic high purity titanium, has a specific gravity of only 4.1—substantially less than that of any other presently available titanium alloy.

According to the developers, the addition of 20% aluminum is significant because up to now only about 8% aluminum could be added without making titanium alloys unworkable. (Aluminum additions are important because they provide high temperature strength and resistance to oxidation.) The use of electrolytic titanium plus the addition of 2% vanadium to increase strength, has resulted in an alloy which is said to possess outstanding high temperature strength and oxidation resistance. In fact, the alloy forms an

MORE WHAT'S NEW IN MATERIALS

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Riehle-Losenhausen Fatigue Testing Equipment applying stress to 60" concrete beam in Department of Theoretical and Applied Mechanics, College of Engineering, University of Illinois. This equipment is being used in a three-year study of cumulative fatigue damage to concrete as used in highways.

Machine duplicates actual stress-and-rest conditions

Flexural stresses of varying magnitude and sequence are delivered to material specimens and assemblies by this RIEHLE-LOSENHAUSEN fatigue testing equipment which simulates functional fatigue conditions. The basic system consists of a control console, a pulsator, a programmer and separate loading cylinders.

Loads of varying magnitude are followed by either rest periods or by application of high static overloads.

TESTS ENTIRE ASSEMBLIES

Through the use of a steel testing stand, the RIEHLE-LOSENHAUSEN machine easily accommodates complete structural assemblies such as the following: wings, fuselages, tails and other components of aircraft frames; machinery and engine parts and assemblies; hull sections of ships; girders and joints of bridges; pre-stressed concrete beams and built-up timbers. Separate loads can be applied at various points.

Whatever your materials testing problems might be, there is a RIEHLE complete standard machine or custom built unit to meet your strictest requirements. Capacities range from 10,000 to 400,000 pounds.

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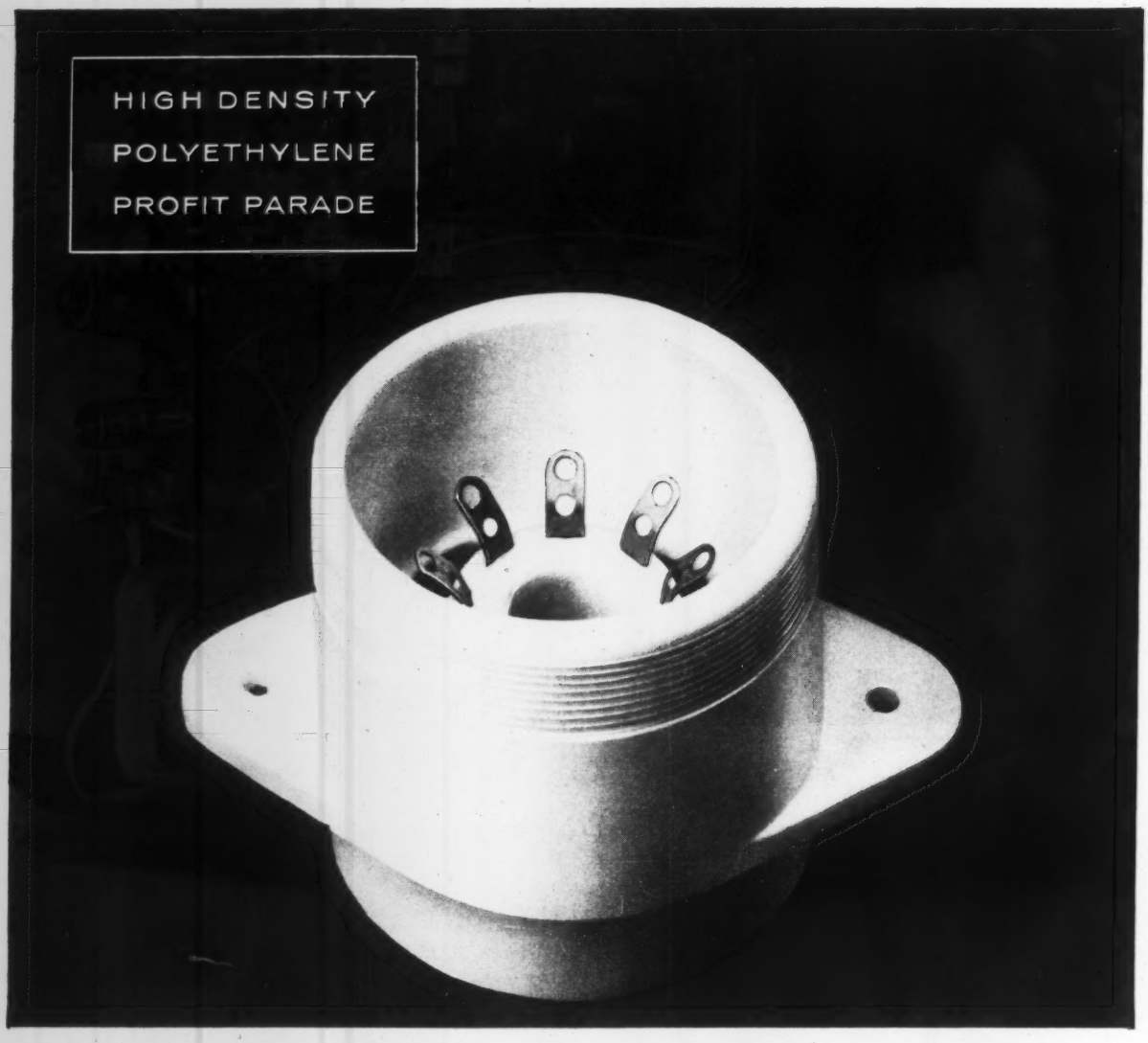

New Part Holds the Line Against Rising Costs

If you are battling to keep costs down you should know about Grex high density polyethylene. Reduction in manufacturing costs is one of the many advantages in specifying parts made of this new Grace plastic.

The TV tube socket shown here helps hold the line against rising costs for many leading manufacturers. It is injection molded for significantly less than is possible to produce competing sockets which can only be made by more costly fabricating methods.

Consider these other advantages of Grex. It is hard, stiff and tough enough to take a beating in installation or use without breaking, cracking or chipping. It is the only thermoplastic that can be boiled or frozen without losing its shape or impact strength. It has outstanding electrical insulating properties, is resistant to most corrosive chemicals and provides flame-retardance if required, as in this electrical application.

If these unique properties bring a Grex application to mind, decide to call in the experts on high density polyethylene now. Grace has the production facilities, technical service and experience to help put your product in the Grex profit parade. We're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION CLIFTON, NEW JERSEY

For more information, turn to Reader Service card, circle No. 518

Tube socket for TV sets demonstrates outstanding Grex electrical properties.

Take a look at the technical background on this socket for an idea of what you can expect to gain by specifying Grex for electrical equipment.

Electrical properties. High density polyethylene is one of the most effective electrical insulating materials available. The Grex compound in this socket has a dielectric strength (short time) of 475 volts per mil for ⅛" thickness. With such high resistivity the wall sections were kept thin for fast cycles and economical production. Another advantage of specifying Grex is the stability of its dielectric constant: this socket is stable from 60 cycles per second all the way up to 1,000,000 cycles per second.

Molding considerations. Injection molding of Grex resulted in considerable cost savings over compression molding of thermosetting materials. In order to meet electrical equipment safety requirements, C-1012 Grex flame retardant compound was chosen for the job. Of the five Grex flame retardant compounds available, C-1012 has the highest melt index—6.0—to provide the best flow characteristics and the impact strength needed for the socket.

Mechanical properties. The resiliency and high impact strength of Grex are particularly valuable in this application. While breakage due to riveting socket ears to chassis is a major problem with sockets made of other materials, high impact Grex sockets hold breakage to a minimum. Resiliency simplifies insertion of metal lugs which dig into sockets easily and hold firmly. Resiliency also saves time in installation of threaded caps which are simply pushed over the sockets without stripping threads.

Interested? If you have a job for high density polyethylene count on Grace for help. Now's the time to contact:

Technical Service Department
W. R. Grace & Co., Clifton, N.J.

oxide coating which is said to be self-protecting at temperatures up to 2000 F.

Room and elevated temperature properties of EP 20-2 are given in the accompanying tables. Potential applications include high temperature components such as afterburner shrouds and compressor blades.

TENSILE PROPERTIES OF NEW TITANIUM ALLOYS

Alloy	Form	Condition	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong (in 2 in.), %
EP 90-10	Bar	Hot rolled, air cooled	200	175	6
	Sheet	Quenched from 1400 F	140	115	20
		Aged at 800 F			
		42 min	200	175	6
		56 min	220	200	3
		1 hr, 48 min	240	220	2
	Welded section of hot rolled rod	Air cooled	195	175	5
EP 20-2	Bar	Hot rolled, air cooled	190	170	6
	Sheet	Hot rolled, air cooled	185	165	8

Improved casting process produces

Strong, 'Flaw-Free' Castings

■ Steel castings with tensile strengths as high as 300,000 psi—and completely "flaw-free"—are now available from American Brake Shoe Co.

According to American Brake Shoe, the development is significant because it opens the door to widespread use of castings for critical parts in aircraft and missiles. Although any casting technique offers a number of obvious advantages, none could previously be used for critical applications because various defects (such as inclusions, hot tears and minute flaws) either reduced strength or necessitated excessive weight. With these drawbacks eliminated, designers of highly stressed parts can now specify casting to replace expensive forgings, machined parts, weldments, etc.

Cost and applications

Basically, the process involves careful selection and control of: 1) raw materials and alloying ingredients; 2) size, finish and casting characteristics of the mold material; 3) melting and pouring temperature and conditions; 4) cooling rate; and 5) heat treatment.

The cost of the new castings is, of course, higher than that of conventional castings. However, the castings are not intended to be used in place of conventional castings. Rather, they are competitive with the more expensive fabrication methods. For highly stressed, complex parts requiring a high strength-weight ratio, the new casting process is often the least expensive method.

According to American Brake Shoe, the "high integrity" castings should be considered wherever uniformity, reliability and high strength are primary requirements. They should be considered as replacements for forgings (to avoid expensive low volume production and costly secondary machining); weldments (to avoid expensive jigs, possibly unreliable joints, and complex heat

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treatment); and machined parts (to avoid excessive labor costs).

Specific parts now being produced by the new method include missile launching equipment, jet engine gear case covers, aircraft pylons, and base rings used as the main structural components in the third stage of a still-classified missile.

Future applications should include such things as end closures for solid fuel rockets, dipper teeth for earth moving equipment, and rock bits for oil well drilling equipment.

Properties

The new casting process can produce almost any desired properties by proper selection of the steel to be used. Stainless steels, air hardening steels and other alloy steels can be cast by the process. Depending upon the steel selected, tensile strength can range from 150,000 to 300,000 psi (see accompanying table). Where required, as in some missile components, tensile strengths of 260,000 psi can be guaranteed throughout the casting. Actual values are than about 150,000 psi.)

Where extreme strength is not as important as uniformity of properties, tensile strength will range from 150,000 to 250,000 psi. (At best, tensile strength of conventional steel castings is usually no higher than about 150,000 psi.)

TENSILE PROPERTIES OF SOME CASTINGS

Alloy ↓	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong (in 2 in.), %
8740	285	230	4.5
4340	280	215	6.0
4330	250	200	9.0
H-11	260	205	9.5
17-4 PH	195	165	11.0
410	195	175	10.0

In general, castings made by the new process are said to be:

1. Stronger than castings produced by any other casting method.
2. Completely reliable.
3. Perfectly uniform and homogeneous throughout.
4. Producible in any size and shape.
5. Dimensionally accurate.
6. Less costly than similar parts made by other methods.

How process works

According to American Brake Shoe, there is no one magic formula that produces the high strength, flaw-free castings. "However, even a minor slip in any step in the process will degrade the properties below required levels."

Raw materials—Most steel castings are made primarily from scrap costing about 2-3¢ per lb, and analysis control is rather loose. The high integrity castings use either sponge iron (17¢ per lb) or electrolytic iron (35¢ per lb) and the

***Pouring time** totals only 7 sec.*

PRESSURE SWITCH VALVE
OF COORS CERAMIC

COORS PRECISION CERAMIC PART ENDS CORROSION OF PRESSURE SWITCH

Ceramic valve for respirator so sensitive it can be actuated by infant's breath

Bird Oxygen Breathing Equipment, Inc., of Palm Springs and San Francisco, manufactures a new, compact, precision respirator used by anesthesiologists in delicate surgical procedures and by physicians to treat lung diseases like asthma and emphysema.

Operation of the instrument is dependent upon the extreme sensitivity of a pressure switch . . . a switch so sensitive that the slightest intake of breath causes the respirator to operate and begin breathing for the patient . . . so sensitive that it operates from the breath of a weakened patient, even a new-born infant. The respirator must be able to work perfectly even after years of disuse on the shelf, under conditions of sporadic operation, and under conditions of regular exposure to oxygen, ozone and moisture.

Metal and alloy parts corrode. With every metal or alloy that Bird designers tried as parts for the pressure switch valve, the minute amount of moisture present in the gases used caused an electrolytic action that resulted in adhesion of the metal plunger to the sleeve—a slight seizing, but enough to prevent the valve from operating with the necessary sensitivity. Oxidation was also a problem—the slightest roughening of the smooth surfaces prevented valve from functioning.

Coors Ceramic valve eliminates corrosion. These problems with metal valves were eliminated when Bird used Coors High Strength Alumina Ceramic (type AD-85) in place of metals. Because Coors ceramics do not corrode or seize, and because properly finished ceramic surfaces have a very low coefficient of friction, the pressure switch works perfectly. Also, because of the extreme hardness of the Coors Ceramic, there is little or no wear—the precise fit of the ceramic plunger and sleeve is retained throughout the operating life of the respirator, tested to 20-million cycles of perfect operation!

During manufacture of the ceramic parts, Coors holds tolerances to 0.000025" on both the O.D. of the shaft and the I.D. of the sleeve. Difference in diameters between shaft and sleeve is held to 0.0001-0.0003".

Coors High Alumina Ceramic is a fine engineering material for applications requiring a high degree of corrosion resistance or abrasion resistance . . . also for applications that require high strength under conditions of extreme heat . . . or for any combination of these conditions.

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***from* BORG-WARNER**

New Compactness, Modern Functional Design, Built-In Versatility...

are the features of the new 18- or 30-button Call Director. Simply push a button for regular telephone service, plus interoffice calls, multi-line pickup, conference calls, signalling and other special requirements.

CYCOLAC was specified for housing and handset by Western Electric because of its excellent qualities of rigidity and rugged toughness. The handsome colors add much to the decor of today's modern office—the hard, stain-resistant surface makes it possible to maintain this appearance. CYCOLAC provides maximum serviceability yet affords important economies in production.

For these reasons, CYCOLAC ABS plastic is playing an ever more important role in the design of new products for modern business and industry.

CYCOLAC... ***better in more ways than any other plastic!***

PACESETTER IN
Marbon CHEMICAL
SYNTHETIC RESINS

Division of BORG-WARNER • Washington, W. Va.

also represented by:
WEST COAST: Harwick Standard Chemical Co., Los Angeles, Cal.
CANADA: Dillons Chemical Co. Ltd., Montreal & Toronto
EXPORT: British Anchor Chemical Corp., New York

BW ®
Marbon

For more information, turn to Reader Service card, circle No. 553

Cast missile ring, *made of modified 8740 steel, has a minimum tensile strength of 260,000 psi, a minimum yield of 210,000 psi and elongation of 3%.*

analysis is controlled to within hundreds of a percentage point.

Molding—Molds and cores are made of an undisclosed ceramic mixture specially developed to produce controlled shrinkage in the casting as it cools, good surface finish, and close dimensional tolerances. The molds are made with a large number of risers and are designed so that the poured metal fills every area of the mold within seconds.

Melting—High frequency induction furnaces are used to avoid direct contact of flames or electrical arcs with the molten metal.

Pouring—Pouring temperature is controlled to within a few degrees to insure best metallurgical properties and prompt mold filling. Although it takes a week to prepare the mold for a complex missile part and a few hours to bring the metal to correct temperature, actual pouring from twin ladles takes only a few seconds.

Heat treatment—For ultra high strength castings, a three-stage heat treatment cycle is used (homogenization, austenitization and tempering). Heat and time are precisely controlled and, according to American Brake Shoe, critical dimensions of complex parts do not distort.

Inspection—To insure the absence of flaws, each casting is subjected to a series of rigorous tests. Some

Be sure the TEFLON* you buy has the Qualities you need

Processing can radically change Teflon properties

Take flex life as an example. The Teflon sheet illustrated was quenched to 50% crystallinity, resulting in an excellent flex life of 60,000 cycles. However, through lack of process control, it might have been cooled more slowly, giving a 56% crystallinity and a flex life of 40,000 cycles . . . A LOSS OF 20,000 CYCLES OF FLEX LIFE!

You can be sure of proper processing by specifying Teflon stocks made by Garlock's Plastics Division, the United States Gasket Company. U.S.G.'s years of experience with fluorocarbon resins guarantees you the right properties every time. This, plus assurance of fast delivery anywhere, makes Garlock your prime source of Teflon sheet, rod, tape, tubing, bars, cylinders. Find out more by calling one of Garlock Packing Company's 26 sales offices and warehouses throughout the U.S. and Canada.

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

*DuPont Trademark for TFE Fluorocarbon Resin

United States Gasket

Plastics Division of GARLOCK

For more information, turn to Reader Service card, circle No. 426

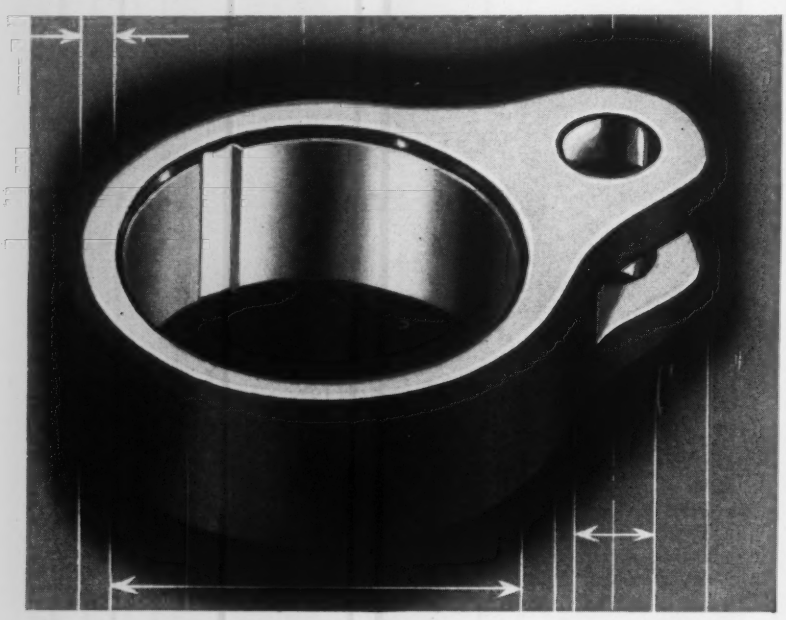
exceptionally close limits...

The photograph shows the connecting rod of an unusual hydraulic pump built by a company whose name is known everywhere.

The finish in the bore of both the large hole and the small hole must be held to very fine profilometer reading.

In addition, the axes of these two holes must be parallel to each other within exceptionally close limits. Naturally, the user of a cast bronze part such as this turns to Bunting in order to assure strictest adherence to his print and specifications.

For the unusual, as well as the usual, in bearings, bushings, bars, or special parts of cast bronze, sintered bronze, or Alcoa aluminum, try Bunting first.



BUNTING SALES ENGINEERS in the field and a fully staffed Product Engineering Department are at your command without cost or obligation for research or aiding in specification of bearings or parts made of cast bronze or sintered metals for special or unusual applications.

...ask or write for your copy of...

Bunting's "Engineering Handbook on Powder Metallurgy" and Catalog No. 58 listing 2227 sizes of completely finished cast bronze and sintered oil-filled bronze bearings available from stock.

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BEARINGS, BUSHINGS, BARS AND SPECIAL PARTS OF CAST BRONZE OR SINTERED METALS • ALCOA® ALUMINUM BARS

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What's new IN MATERIALS

of the tests include x-ray examination, isotope radiography, and fluorescent penetrant examination. Defects that would normally be acceptable in conventional castings are considered cause for rejection.

Silicone Rubber Has High Tensile Strength

What is claimed to be the first silicone rubber compound with a tensile strength over 2000 psi is now available in the form of extrusions, moldings and spliced parts, either by themselves or in combination with metals, reinforcing fabrics or with TFE resin bonded to the surface of the parts.

Other properties include:

1. A tear strength of over 300 lb per in.
2. Good weather, sunlight and ozone resistance.
3. Good electrical insulation characteristics.
4. Good heat resistance at tem-

HOW M-777 COMPARES WITH AMS 3345

	AMS 3345 Min Requirements	M-777 Typical Properties
ORIG PROPERTIES		
Ten Str, psi	1000	2050
Elong, %	500	600
Tear Str, lb/in.	150	325
Hardness (durometer)	A50 ±5	A50
Compr Set (aged 70 hr at 300 F), %	73	40
AFTER AGING 70 HR AT 212 F		
Ten Str Chg, %	-	−10
Elong Chg, %	-	−10
Hardness Chg, pts	-	+3
AFTER AGING 70 HR AT 400 F		
Ten Str Chg, %	−40	−20
Elong Chg, %	−50	−20
Hardness Chg, pts	0 to +20	+5
AFTER AGING 70 HR AT 300 F IN ASTM NO. 1 OIL		
Ten Str Chg, %	−40	−35
Elong Chg, %	−40	−30
Hardness Chg, pts	−40 to +5	−10
Volume Chg, %	0 to +15	+10

IT'S ICE-SLICK

Won't Stick at 30° Below

Try C/R K-400 Cups for Smoother Power Cycles

Any time you face the problem of reducing cylinder cup breakaway or sliding friction, chattering or freezing, come see us. We're reasonably certain that Chicago Rawhide's Sirvis Leather K-400 cups can help you. Their specialty is easy sliding — particularly in vacuum cylinders at sub-zero temperatures and in pneumatic cylinders at ambient temperatures and low pressures. Tests show a 50% reduction in breakaway and sliding friction over standard leather cups at ambient temperatures . . . and these K-400 cups are functioning beautifully in applications at -30° F. In another test, C/R Sirvis K-400 cups were run well over one million cycles at 20″ of vacuum with negligible leakage and wear.

So if you are trying to design a new, smooth-working, low-friction pneumatic cylinder — or take the bugs out of an old one — jot down C/R K-400 cups and call us.

CHICAGO RAWHIDE MANUFACTURING COMPANY

SIRVIS DIVISION, 1227 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario
Export Sales: Geon International Corp., Great Neck, New York
C/R PRODUCTS: C/R Shaft & End Face Seals • Sirvene (synthetic rubber) molded pliable parts • C/R Non-metallic gears

C/R

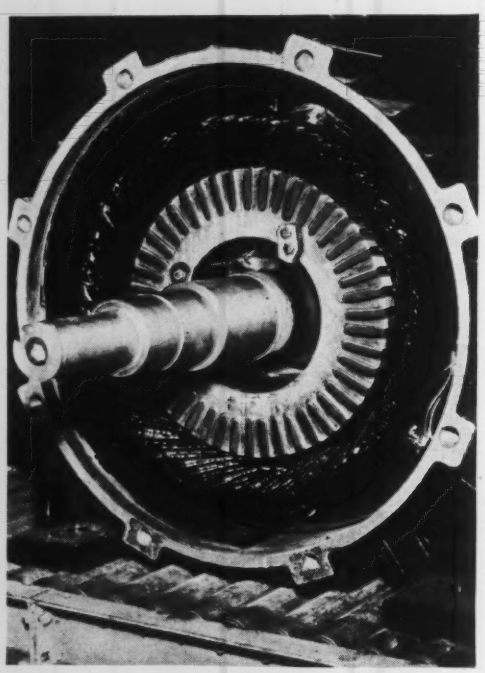
For more information, turn to Reader Service card, circle No. 479

Copper Alloy Bulletin

BRIDGEPORT BRASS COMPANY

Bridgeport "CONTACT BRONZE" Cuts Costs of Electrical Spring Contacts by 25%

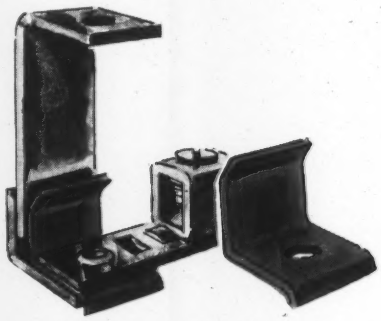
This outstanding Bridgeport alloy offers many of the superior mechanical qualities of phosphor bronze at considerably less cost... with a superior electrical conductivity rated at 22% IACS at 68° soft. Designed to meet the exacting standards of the electronics industry, Bridgeport "Contact Bronze" (Alloy 92) maintains spring properties even after difficult forming operations. Add corrosion resistance and "Contact Bronze" is a guarantee of efficient and reliable performance throughout your product's service life. Here are a few examples:



ELECTRIC MOTORS

The 100-hp 4-pole motors driving extruder-type machines in a dog-food plant were causing frequent production breakdowns. The material processed was so highly viscous that the motors were stalling, jogging and burning out. To meet the high torque, high slip necessary to minimize stalls and also to provide the high thermal capacity required, Allis-Chalmers Company designed a special motor rotor utilizing Bridgeport "Contact Bronze" in place of copper. Burnouts from overload were eliminated and the performance of the "Contact Bronze" motor was so excellent that Allis-Chalmers received an order for another sixteen of the same type.

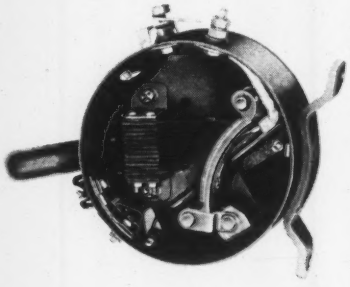
PRESSURE CLIPS



American Electric Switch Division, Clark Controller Company, found that "Contact Bronze" fitted their needs for a lower cost alloy for pressure clips. Its electrical conductivity, corrosion resistance, spring and formability properties were more than comparable with other alloys... at 25% less cost.

TRAILER TRUCK BRAKING SYSTEM

Warner Electric Brake & Clutch Company manufactures an ingenious electric brake system for heavy-duty trailer trucks. Through a graduated series of Bridgeport "Contact Bronze" leaves, it allows the driver to adjust torque instantly and smoothly to suit load and road conditions. The conductivity and performance-proved spring properties of "Contact Bronze" provide added safety and long-haul reliability.



✓Check the Savings INVESTIGATE "CONTACT BRONZE"

Electronic and mechanical devices, switch gears, circuit breakers, contacts, terminals are just a few of the applications. There are thousands of others. Call your nearest Bridgeport Sales Office or write Dept. 3506 for full details of Bridgeport Contact Bronze. Bridgeport Brass Company, Bridgeport 2, Conn.

For more information, turn to Reader Service card, circle No. 423

***Typical parts** made of new high strength silicone rubber compound.*

peratures up to 500 F.

5. Low temperature flexibility at temperatures down to –105 F.

The new compound, designated M-777, was developed by Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn. (For information on two other high strength silicone rubber compounds, see *Materials & Methods*, May '57, p 187.)

More Information on René 41 Nickel Alloy

by R. J. Morris*

René 41 nickel-base sheet alloy has evolved in the short span of three years from an experimental turbine bucket material to the stage where it is now commercially available from nine metal producers in the form of sheet, bar, billet and investment castings (see M/DE, Feb '59, p 166).

The superalloy can be vacuum melted either by induction or consumable electrode melting techniques. Both methods are presently being used to cast the alloy into ingots weighing up to 3000 lb. Present trends indicate that the alloy can be cast in any ingot size. This feature, important from an economic viewpoint, is probably one of the biggest

* The author is associated with General Electric Co., Rocket Engine Section, Cincinnati 15, Ohio. René 41 is a trademark of the General Electric Co.

*

FOR MECHANICAL APPLICATIONS...

AT HIGH SPEEDS...

HIGH TEMPERATURES...

OR WHERE CHEMICAL CORROSION IS A PROBLEM

*carbon-graphite especially designed for mechanical applications

Purebon is: (1) stable at high temperatures, (2) light weight, (3) readily machinable, (4) low cost where molded to size, (5) chemically inert, (6) oxidation resistant, and (7) provides constant friction. And, Purebon is self-lubricating ... especially suitable as seals, bearings, blades and other sliding or rotating parts. Purebon may be the best solution to your problem.

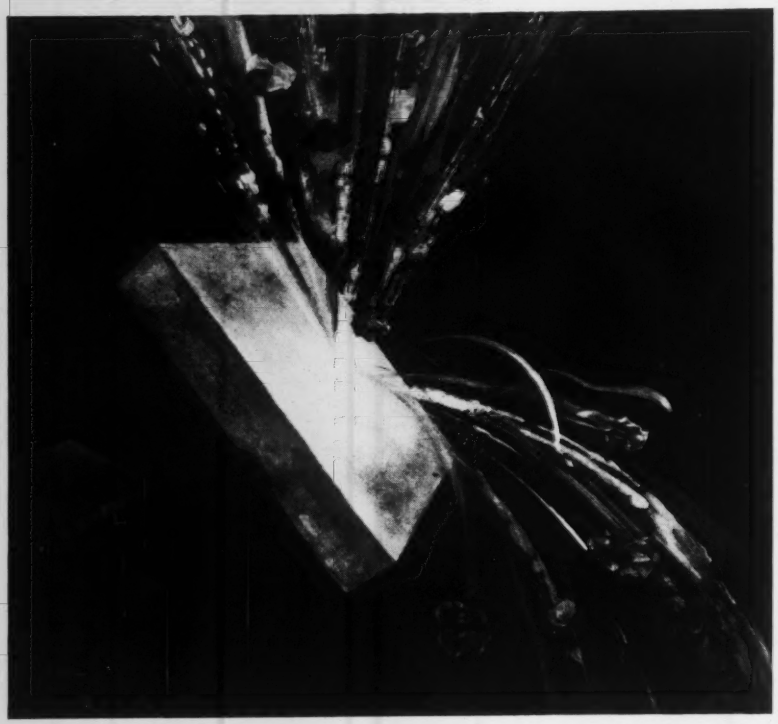
Request Bulletin No. 59 or see Sweet's Product Design File

PURE CARBON CO., INC.

447 HALL AVE., ST. MARYS, PENNSYLVANIA

Rampart against Destruction

Closest approach to the indestructible material needed to combat extreme forces of corrosion, abrasion, heat and impact is a unique fused cast refractory . . . another development of advanced materials technology at Carborundum. For more information on this remarkable product, see below.



Fused-cast refractory resists extreme corrosion, wear, heat

Melted in electric furnaces and poured into moulds at 4500 F to form solid blocks and similar shapes, fused-cast refractories offer unique structures and properties not obtainable in any other refractory material. Dense, strong and impermeable, they top all man-made materials in resistance to wear. Inert to chemical action, they resist corrosion at virtually all temperatures. Ability to take considerable impact is a special feature.

HIGH TEMPERATURE APPLICATIONS already include glass melting tanks where temperatures range close to 3000 F, as well as hearth pavings and skid rails for metallurgical furnaces.

CORROSION RESISTANCE has been demonstrated in electrolytic cell liners for magnesium production, liners for synthesis gas generators and guides for pickling tanks.

RESISTANCE TO WEAR AND IMPACT has resulted in use in coke and sinter chutes and in ball mills for grinding abrasive materials.

Boundless opportunities exist for many other applications in design engineering, where problems call for unconventional solutions. To learn more about this interesting material . . .

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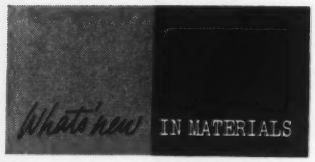


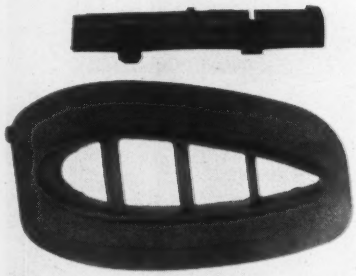


***Fig 1**—Investment castings made of René 41 are used in jet engines.*

reasons why the alloy has achieved true "production status" and commercial success.

Applications

René 41, introduced last year (see M/DE, Nov '58, p 143), first attracted attention as a possible lightweight substitute for heavy forgings in jet engines. In this application, René 41 investment castings (see Fig 1) are butt welded to sheet which in turn is welded to flanges. Other uses for René 41 in jet engines include turbine casings, afterburner parts and nozzle diaphragm partitions.

The alloy is also well suited as a high temperature bolting and fastener material for high-Mach airframe parts.

How alloy was developed

René 41 is a modification of GE's nickel-base alloy M-252, an age hardenable alloy containing titanium and aluminum. In producing René 41, titanium and aluminum contents

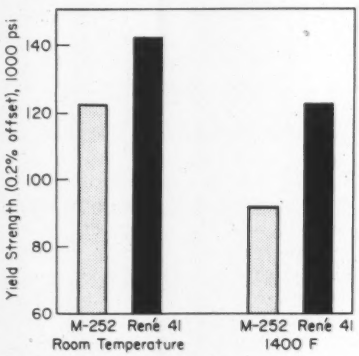
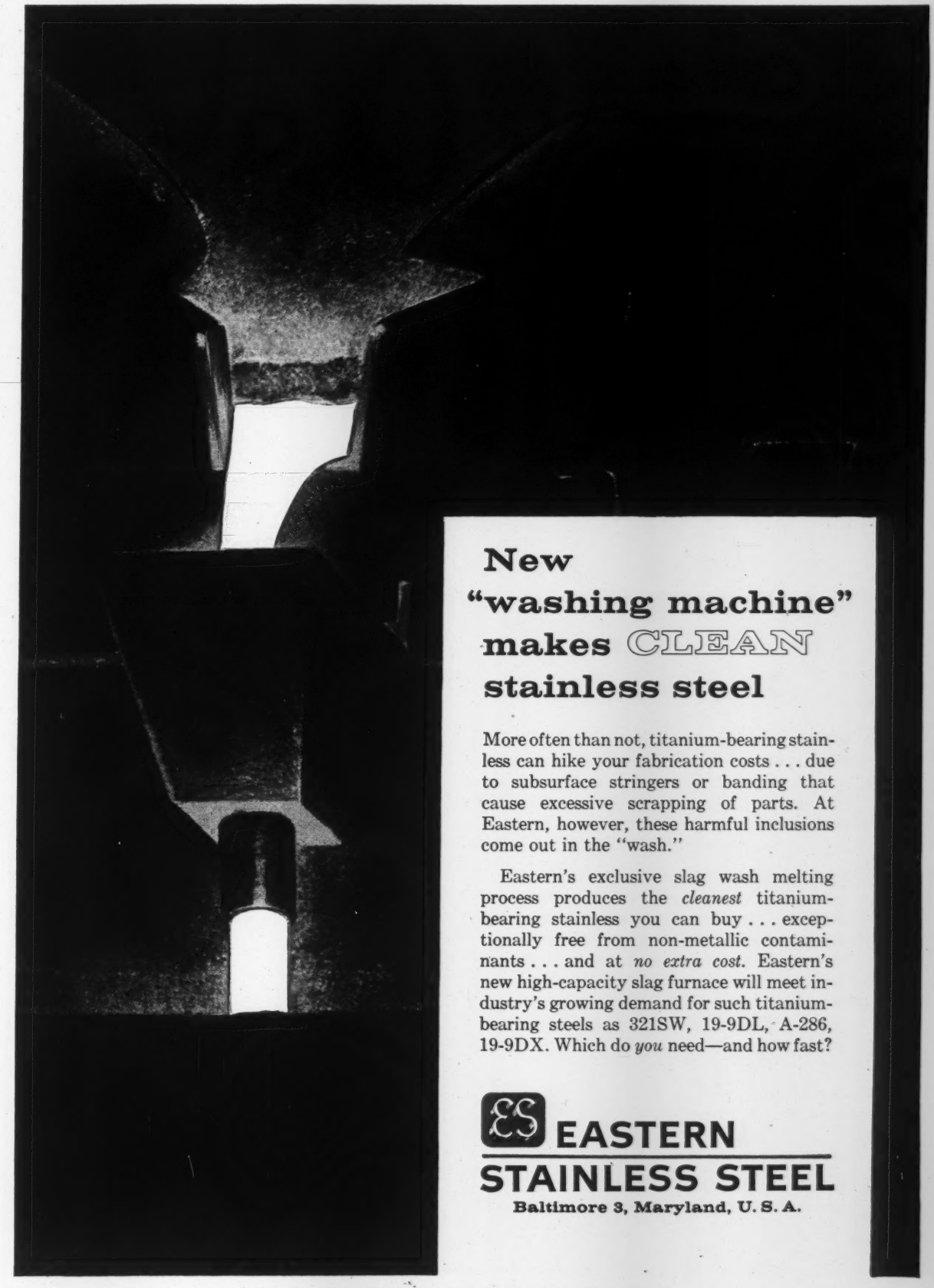


***Fig 2**—Yield strength of René 41 and M-252 at room temperature and 1400 F.*



New "washing machine" makes CLEAN stainless steel

More often than not, titanium-bearing stainless can hike your fabrication costs . . . due to subsurface stringers or banding that cause excessive scrapping of parts. At Eastern, however, these harmful inclusions come out in the "wash."

Eastern's exclusive slag wash melting process produces the *cleanest* titanium-bearing stainless you can buy . . . exceptionally free from non-metallic contaminants . . . and at *no extra cost.* Eastern's new high-capacity slag furnace will meet industry's growing demand for such titanium-bearing steels as 321SW, 19-9DL, A-286, 19-9DX. Which do *you* need—and how fast?

EASTERN STAINLESS STEEL

Baltimore 3, Maryland, U. S. A.

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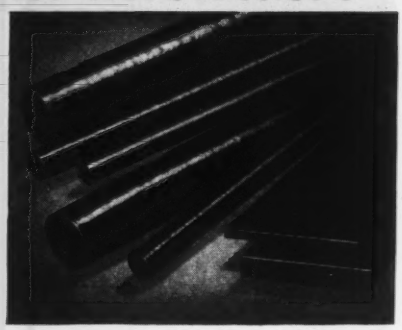
Chemically Inert Dry Bearing Material

Chemloy 719*

use without lubricant!



Chemloy 719 is proving to be the most *universal* dry bearing material ever offered to industry:

. . . because its extremely low coefficient of friction invites use where lubrication is impossible, impractical or undesirable.

. . . because it may be used on both sliding and rotating applications over a wide temperature range.

. . . because it is impervious to practically all known chemicals, solvents or corrosives.

. . . because it is excellent under vibration or shock service conditions.

. . . because it will not conduct electricity or cause galvanic corrosion.

Chemloy 719 is available in all basic forms—such as sheet, rod or tubing—or in parts molded or machined to specifications. Get full details.

*The best in Teflon based bearing materials.

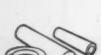
Request Bulletin T-120 and Price Sheet No. 126, or send b/p specs. for quotation on molded or machined parts. Crane Packing Company, 6460 Oakton St., Morton Grove, Ill. *(Chicago Suburb). In Canada: Crane Packing Co., Ltd., Hamilton, Ontario.*

Teflon is a DuPont Trademark

John Crane

MECHANICAL PACKINGS

SHAFT SEALS



TEFLON PRODUCTS

LAPPING MACHINES

THREAD COMPOUNDS

CRANE PACKING COMPANY

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TABLE 1—COMPOSITION OF RENÉ 41 AND M-252 (%)

Alloy ➡	M-252	Rene 41
Carbon	0.10-0.20	0.12 max
Cobalt	9.0-11.0	10.0-12.0
Molybdenum	9.0-10.5	9.0-10.5
Chromium	18.0-20.0	18.0-20.0
Titanium	2.25-2.75	3.0-3.3
Aluminum	0.75-1.25	1.4-1.8
Silicon	0.50 max	0.50 max
Manganese	0.50 max	0.10 max
Iron	5.0 max	5.0 max
Boron	0.003-0.010	0.003-0.010
Nickel	Balance	Balance

of M-252 were increased, carbon was reduced, and the cobalt range was increased slightly to improve hot workability (see Table 1).

Strength, weldability

Tests show that yield strength of the modified alloy is significantly higher than that of M-252 at both room and elevated temperatures (see Fig 2). The alloy has superior strength properties on a strength-weight basis in the temperature range 1000-1800 F, as compared with other high temperature alloys (see Fig 3).

René 41 is formable and weldable, and production parts are currently being manufactured in many shops across the country. The alloy can be welded by resistance and fusion welding techniques. Filler materials that can be used include René 41 wire and sheared strip, and Hastelloy X or W wire.

Heat treatment

Various heat treatments have a

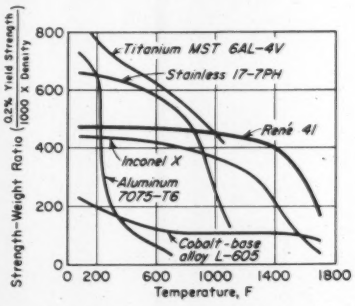


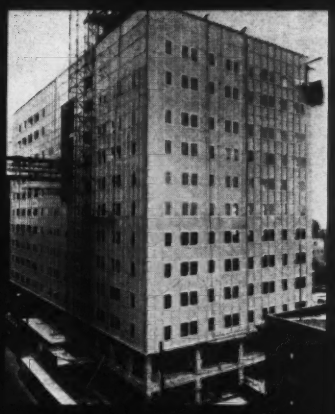
***Fig 3**—How René 41 compares with other high temperature alloys on a strength-weight basis. (Based on curves by G. D. Cremer, Solar Aircraft Co.)*

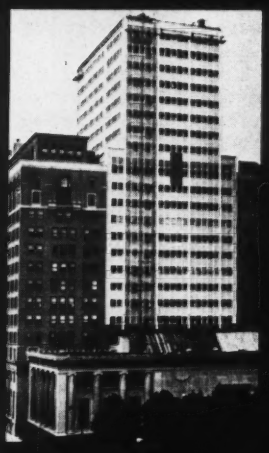
Wilmington, Delaware

630

DISCO WINDOWS

32,000 pounds of Wolverine extruded shapes





Wilmington, Delaware

937

DISCO WINDOWS

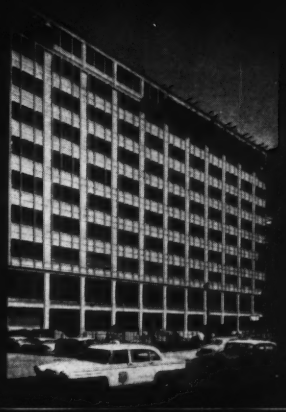
42,000 pounds of Wolverine extruded shapes

Boston, Mass.

676

DISCO WINDOWS

50,000 pounds of Wolverine extruded shapes



2243 MODERN WINDOWS BY DISCO MADE FROM WOLVERINE EXTRUDED ALUMINUM SHAPES!

Corrosion-resistant, warp-free, weight-saving . . . as modern as tomorrow . . . are the Disco reversible aluminum windows manufactured by the Decatur Iron and Steel Company, Decatur, Alabama.

Illustrated here are three buildings containing 2243 modern Disco windows. They are manufactured from 124,000 pounds of extruded aluminum shapes produced in the Decatur, Alabama plant of Wolverine Tube.

Wolverine is proud that its extruded shapes and extrusion facilities are helping Disco, and other aluminum window manufacturers, bring new styles and convenience to American homes and buildings.

Wolverine Tube's extrusion alloys are EC, 1100, 3003, 6061, 6062 and 6063. Extruded aluminum products include tubing, bar, and solid, semi-hollow and hollow shapes—all in a wide range of sizes. Wolverine also produces drawn aluminum tube.

If your company uses aluminum tube or extruded aluminum shapes why not get a Wolverine quote before placing your next order? You'll appreciate Wolverine quality and service. Write, too, for the Wolverine Aluminum Catalog.

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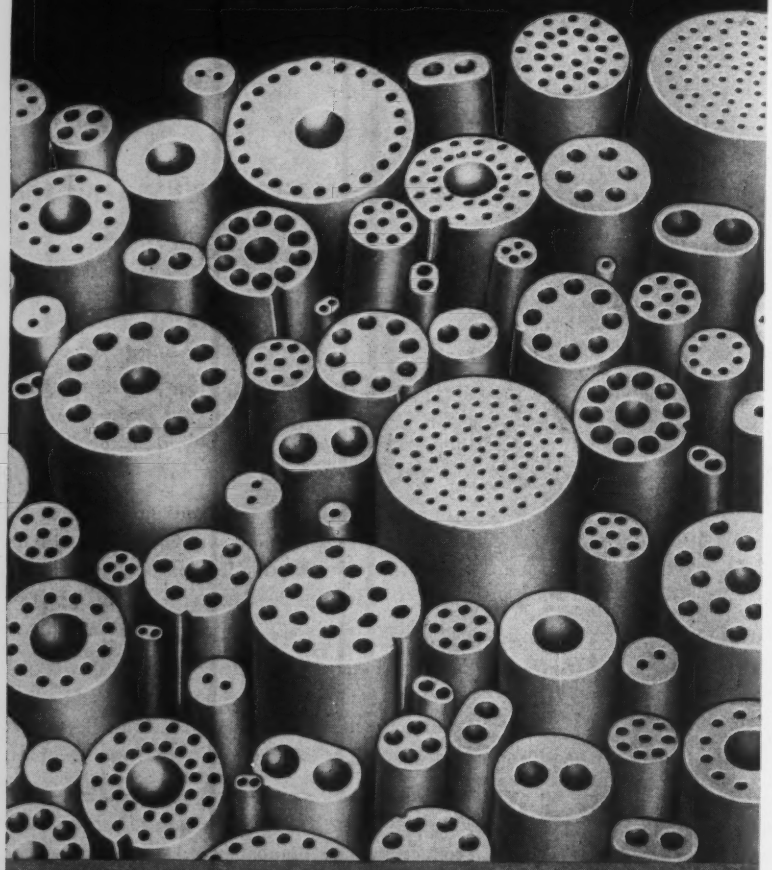
HIGH TEMPERATURE! ALUMINA OR MULLITE



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High-temperature ceramic insulators! Sizes .020 and larger! 1-inch, 2-inch and 3-inch lengths! Special sizes, shapes and lengths and multiple bore quickly available.

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1959-OUR 40th ANNIVERSARY

McDANEL
REFRACTORY PORCELAIN COMPANY
BEAVER FALLS · PENNSYLVANIA

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powerful effect on the mechanical properties of René 41, since it is a precipitation hardening alloy.

In order to make René 41 sheet soft for forming, the material should be heat treated for a short time at 1975 F, then water quenched. Formed and welded René 41 parts should be given a solution heat treatment for 30 min at 1950 F, then air cooled. This heat treatment serves two purposes: 1) it acts as a stress relief for the welded areas, and 2) it acts as a solutioning treatment for the hardening precipitate.

Parts designed for service at temperatures approaching 1400 F should be heat treated for 16 hr at 1400 F. This heat treatment increases hardness and develops maximum strength in the material. Parts designed for long-time service at 1500-1800 F should be solution heat treated at 2150 F, then aged at 1650 F. Solution heat treatment causes some grain growth which benefits creep-rupture properties of the nickel-base sheet alloy.

Rubber Seals Are Radiation Resistant

Radiation resistant rubber seals are now available from Presray Corp., Pawling, N. Y. for use in nuclear reactors and other nuclear devices. The seals are made from a new rubber compound called No. 1704 that resists radiation without breakdown. Other rubber compounds crack, become gummy and generally deteriorate when exposed to radiation for any length of time, according to the producer.

The company does not say what type of rubber is used in the compound. However, it does say that the compound contains "anti-radiation" chemicals.

Lightweight Firebrick

An improved insulating firebrick is said to be lighter in weight than any firebrick now available.

The material is available in two grades, K-20 and K-23. The K-20 firebrick weighs 1.7 lb per 9-in.

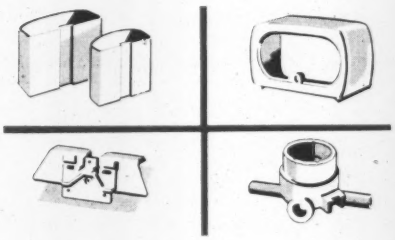
Thermaflow® Tips

News about high-strength molding compounds

Atlas Powder Company, Wilmington 99, Delaware
In Canada: Atlas Powder Company, Canada, Ltd., Brantford, Ont.

New Thermaflow 105 saves 20% over other high-strength plastics

If you've been interested in using high-strength plastics in products now made of metal or conventional plastics—but found the price tag too steep . . . here's news. New Thermaflow 105 reinforced polyester premix gives you a balance of strength, moldability, surface finish, chemical and electrical properties—at a cost about 20% lower than other high-strength compounds. It's the best buy yet in terms of strength per dollar.



An "idea" material

This new combination of performance and price opens up endless new design possibilities. Use it for new quality and economy in TV and radio cabinets, air conditioner housings, appliance parts, instrument cases, tubes, buckets, panels, tanks. You name it . . . we'll help you do it.

Take a look at the characteristics listed here. Remember—you'll get maximum benefits when you design to utilize its high-strength, corrosion resistance, and consistently high quality to the utmost. It's easy to use, too . . . pulls apart readily to load in molds, and has long stability in storage.

MOLDED PROPERTIES

Specific gravity	1.87
Flexural strength, psi	
*ASTM bar	20,000
**Cut specimen	16,000
Flexural modulus (psi x 10^6)	1.6
Izod impact-notched, ft./lbs./in. notch	
*ASTM bar	12.0
**Cut specimen	4.5
Compressive strength, psi	18,000
Heat distortion point, 264 psi	>450° F.
Barcol hardness	65
Water absorption, %	
24 hours @ 23° C.	0.14%
24 hours @ 100° C.	0.75%

*ASTM bar—Test results achieved with a sample molded under ideal laboratory conditions to achieve maximum strength.

**Cut specimen—Test results achieved on a number of samples cut from molded parts at random direction to any possible glass alignment. Results reported are the average of several tests.

NOTE: Common practice reports test results in terms of the maximum values available under ideal conditions. "ASTM bar" figures are listed here to permit comparison of Thermaflow 105 with other similarly reported materials.

ELECTRICAL PROPERTIES

Arc resistance, sec.	130 sec.
Dielectric strength (⅛" thick)	
v/mil short time	230 v/m
step by step	210 v/m
Dielectric constant (1 mc.)	5.05
Dissipation factor (1 mc.)	0.009

STRENGTH RETENTION

	Flexural Strength, psi	Flexural Modulus x 10^4	Appearance
Original sample	16,000	1.58	—
24 hours	After Test	After Test	
H_2O @ 100° C.	13,400	1.21	excellent
24 hours 10% boiling NaOH	13,800	1.09	good
24 hours 10% boiling HCl	10,500	0.87	surface good—pigment bleached white

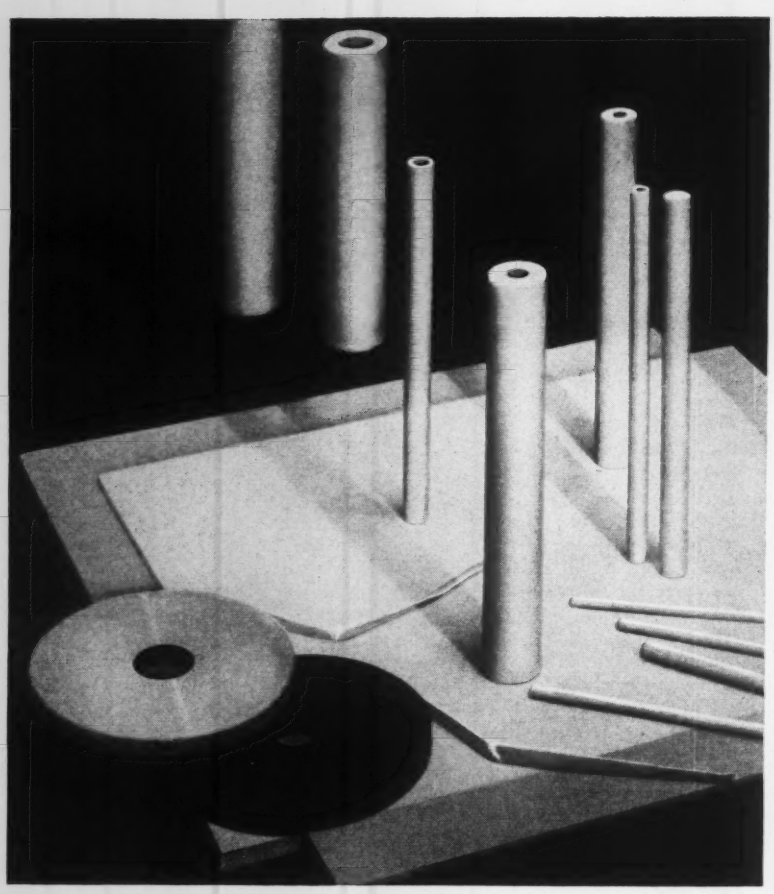
Price Schedule (f.o.b. Wilmington; Net 30 days)
Standard Colors: grey, tan, black

1 carton — (80 lbs.)	— $ .64/lb.
5 cartons — (400 lbs.)	— .48/lb.
24 cartons — (1,920 lbs.)	— .42/lb.
120 cartons — (9,600 lbs.)	— .41/lb.
252 cartons — (20,160 lbs.)	— .40/lb.
less than 1 carton	— 1.00/lb.

Get full facts today—

Write for catalog of Thermaflow materials, and for case histories of their use by leading molders.

For more information, turn to Reader Service card, circle No. 422



For TEFLON* in any form...
CALL ON R/M

Benefit from Raybestos-Manhattan's long experience in the use of "Teflon" and ample facilities for its fabrication. Whether your needs can be met by stock sizes and shapes or require custom made parts, R/M can help you.

R/M makes a broad range of rods, tubes, thin wall tubing, bondable tape and sheets—and new sizes are constantly being added. One of the newest sizes, for example, is 1/32-in.-thick "Teflon" in 36 x 36 in. sheets.

Where custom fabrication is needed, R/M is equipped to extrude, mold or machine "Teflon"—the choice depending on your individual design and quantity requirements.

Whenever "Teflon" is to be specified in a design, don't hesitate to contact your nearest R/M district office for friendly, competent help. And write now for informative literature.

*A Du Pont trademark

R/M

RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION FACTORIES: MANHEIM, PA.; PARAMOUNT, CALIF.

Contact your nearest R/M district office listed below for more information or write to Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

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LOS ANGELES 58 • MINNEAPOLIS 16 • NEW ORLEANS 17 • PASSAIC • PHILADELPHIA 3
PITTSBURGH 22 • SAN FRANCISCO 5 • SEATTLE 4 • PETERBOROUGH, ONTARIO, CANADA

RAYBESTOS-MANHATTAN, INC. Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber
Sintered Metal Products • Rubber Covered Equipment • Abrasive and Diamond Wheels • Brake Linings
Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

For more information, turn to Reader Service card. circle No. 396

"straight" and the K-23 brick 1.85 lb. The firebrick is also said to have low thermal conductivity. It is marketed by Babcock & Wilcox Co., Refractories Div., 161 E. 42nd St., New York City.

The firebrick can be cut, drilled and shaped with ordinary woodworking tools. It can be fitted with pins without danger of breakage.

Glass-Phenolic Plastic Resists Thermal Shock

A glass-phenolic laminate for missile and aircraft structural parts operating in the temperature range of 700-1000 F has been developed by Riverside Plastics Corp., 220 Miller Rd., Hicksville, N. Y. The producer says the material, designated TRC-X, has been approved by the military for use in at least one of the current operational missiles.

Thermal shock resistance

Chief advantage of the new material is its good thermal shock re-

PROPERTIES OF TRC-X LAMINATE

PHYSICAL PROPERTIES	
Coef of Ther Exp (500 F), per °F	3.2×10^{-6}
Ther Cond, Btu/hr/sq ft/°F/in.	1.2
Specific Heat (500 F), Btu/lb/°F	0.30
MECHANICAL PROPERTIES	
Tensile Strength, psi	49,000
Flexural Strength, psi	87,000
Flexural Modulus, 10^6 psi	3.8
Compressive Strength (edgewise), psi	49,000

***Laminate** does not blister or delaminate after a rapid temperature change from room temperature to 1000 F.*

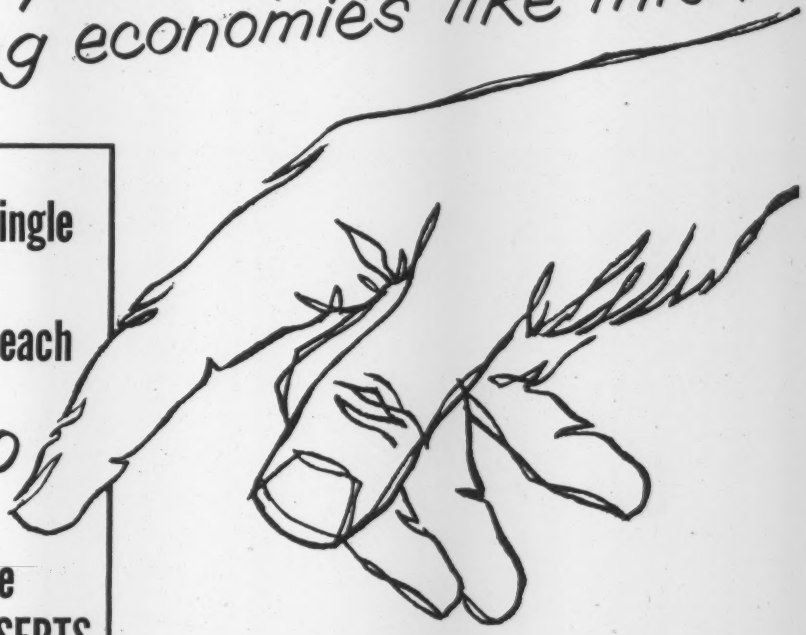
Can you put your finger on machining economies like this?

Cost of 800 brazed single point tools at approximately $3.50 each

TOTAL
$2,800.00

Cost of 100 square CARMET INDEXABLE INSERTS with 800 cutting edges at

APPROX.
$100.00

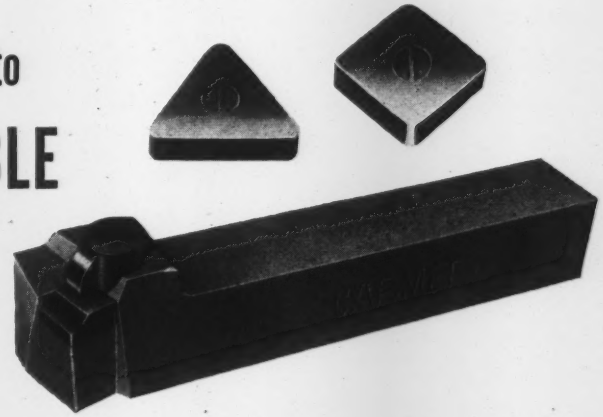


In addition to these savings on machining, you gain in high production rates, longer tool life, in longer tool storage and inventory, as well as tool change downtime.

Over 9 styles and 109 sizes Carmet cadmium plated tool holders. 6 carbide grades for machining almost all materials from wood and plastics to high alloy steels.

then it's time to switch to

CARMET® INDEXABLE INSERTS AND TOOL HOLDERS



See your Carmet Distributor now—or write to Carmet Division, Allegheny Ludlum, Detroit 20, Michigan.

147

Write for New-Revised CATALOG C-16-B CARMET CEMENTED CARBIDES FOR INDUSTRY

This 32-page book contains revised prices and complete specifications on Carmet's full line of cemented carbide tipped tools, blanks and holders. Speed and feed charts, grade comparisons and ordering information included.

ADDRESS DEPT. MM-23

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CEMENTED CARBIDE DIVISION OF
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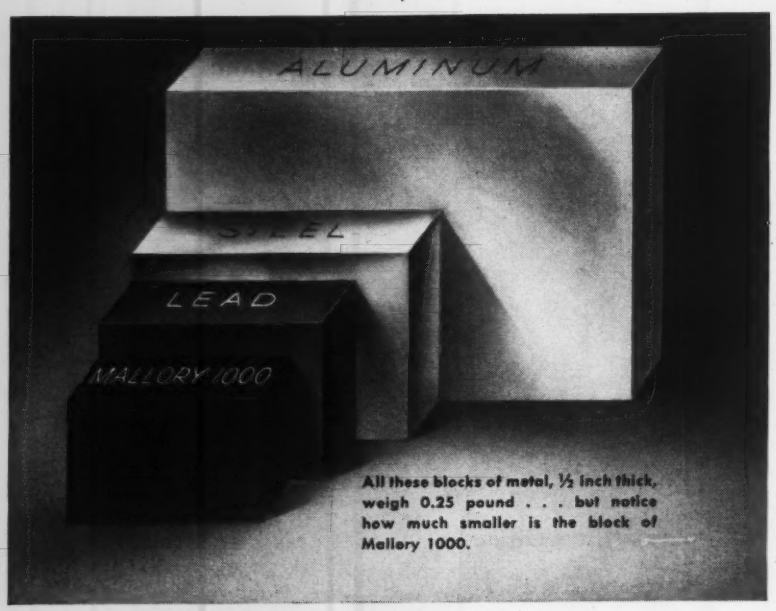
When you need density call on MALLORY 1000 METAL



All these blocks of metal, ½ inch thick, weigh 0.25 pound . . . but notice how much smaller is the block of Mallory 1000.

Over six times as dense as aluminum . . . half again as dense as lead . . . Mallory 1000 metal enables you to put a lot of mass into a limited volume. It's ideal for counterweights, balances, gyro rotors. Because it's strong, you don't have to sacrifice structural properties. Because it's readily machined, you can work it economically. Check the unique properties of Mallory 1000 . . . and let us consult with you on ways to apply it in your next design job.

Density	16.96 grams/cc Average
Ultimate tensile strength	112,000 psi. Average
Modulus of Rupture (simple beam, center loaded)	220,000 psi. Average
Elongation (percent in 2")	2.5% Minimum
Hardness Rockwell "C"	24-30
Modulus of Elasticity	40,000,000 psi.
Coefficient of Expansion 25-500°C	5.4 x 10^{-6}/°C
Electrical Conductivity	14.0% IACS
Proportional Elastic Limit (in tension)	25,000 psi.
Yield Strength (0.2% offset)	75,000 psi.
Torsion Modulus (modulus of rigidity)	19,200,000 psi.
Angle of Twist at Rupture	166°
Shear Strength	81,000 psi.

P.R. MALLORY & CO Inc.
MALLORY
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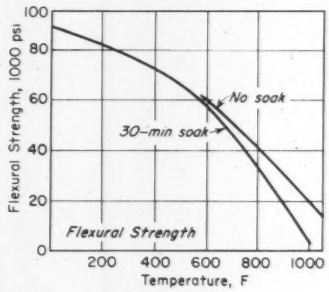
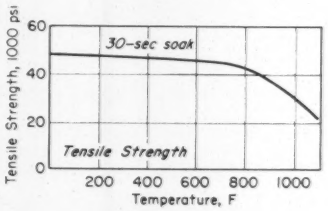
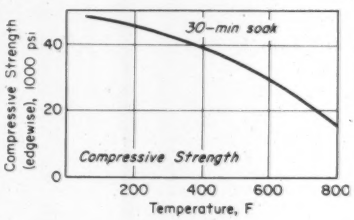
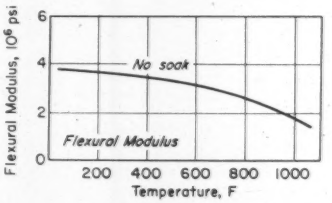
What's new IN MATERIALS









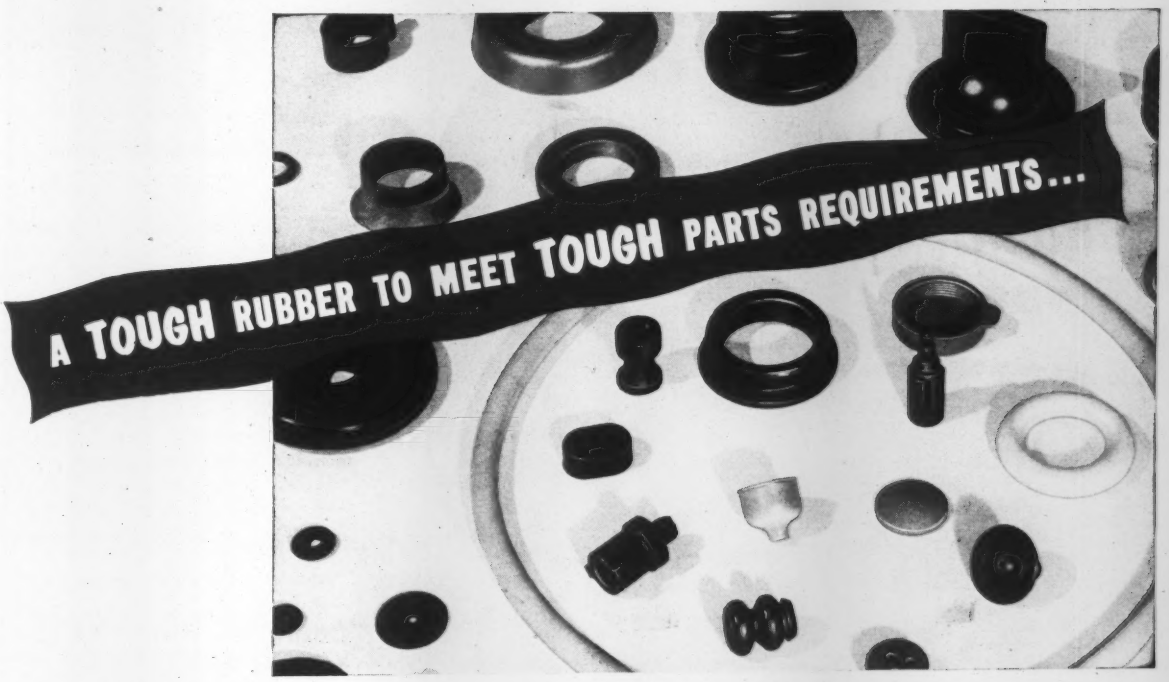
Effect of heat *on properties of TRC-X laminate. All measurements were made at the conclusion of indicated soak time.*

sistance. Tests show the laminate does not blister or delaminate after a rapid temperature change from room temperature to 1000 F. It has a tensile strength of 35,000 psi after a 6-sec temperature change from room temperature to 800 F.

Potential uses

The glass-phenolic laminate is recommended for missile bodies, nose cones, fins and radomes. It is also recommended for a variety of industrial applications.

(continued on p 168)



Colonial's "SILICOL"*

SILICONE RUBBER

NOW **tougher** THAN EVER . . . "SILICOL" has long been the engineers' choice for rubber parts to resist many difficult conditions of which temperature extremes, chemical attack and aging from weather and light are only typical. Because of its versatility, it is specified for all manner of applications from simple appliances to jet planes and guided missiles.

A **new** formulation of "SILICOL" now offers product designers greater versatility than ever. A few of its characteristics which can help you meet tough design requirements easier are: **TENSILE STRENGTH — 1600. ELONGATION—850%.**

The new "SILICOL" formulation is also even more important than ever to aircraft designers and manufacturers . . . In addition to the properties above, it meets AMS 3345 requirements for dry heat resistance, low temperature flexibility and oil resistance.

Whether you are designing new products, or improving existing ones, contact us for full details on "SILICOL" silicone rubber, and information on Colonial's custom rubber compounding and molding service. We can help you meet your "toughest" rubber parts requirements quickly, dependably and economically.

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COLONIAL RUBBER CO.

706 Oakwood Street AXminster 6-9611

RAVENNA, OHIO

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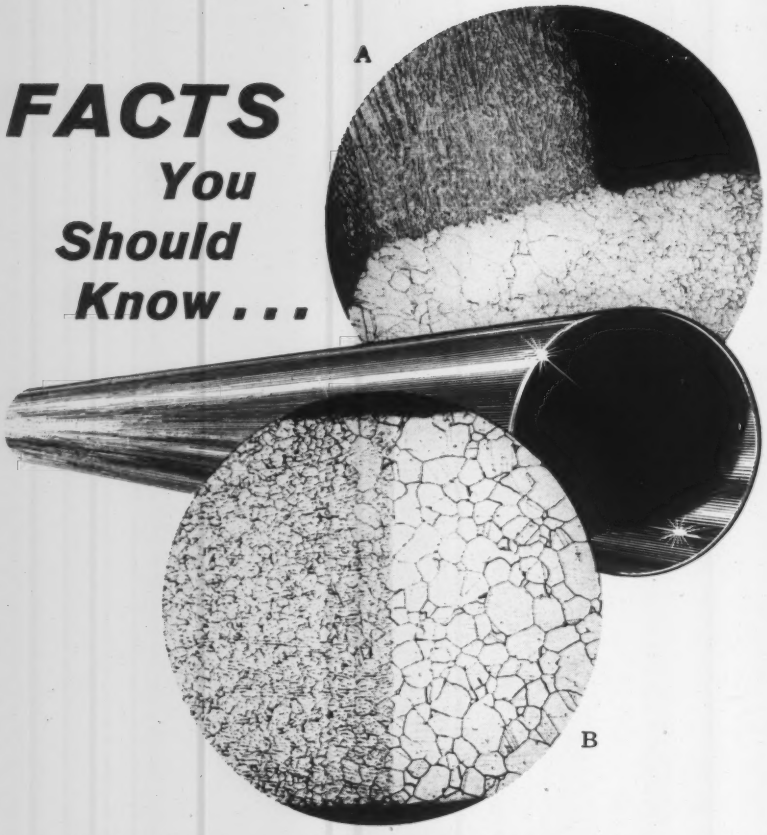
FACTS You Should Know . . .



about the DIFFERENCE in Stainless Steel Tubing — —

Both photographs above show the microstructure of the weld and base metal of Type 304 stainless steel tubes. Photograph A reveals accelerated corrosion of the weld metal due to the presence of delta-ferrite. This tube was manufactured by welding, swaging and annealing, which is an insufficient amount of cold work to produce a high quality, uniformly corrosion-resistant welded tube.

Photograph B shows a typical tube supplied by Wallingford Steel. This tube was produced by the welding and cold drawing process, then inspected with a Magne Gauge to insure no ferrite was present in the weld metal. *Processed and inspected in this manner, Wallingford Cold Drawn Tube is guaranteed to show no preferential attack in weld area.*

All Wallingford welded stainless steel tubing is cold drawn and inspected by Magne Gauge. *Can your suppliers say this about the stainless steel tubing they produce?* Wallingford's manufacturing techniques and quality control checks assure top quality — *yet cost you no more.* Why not purchase *your* tubing where *tonnage is produced on a laboratory basis?*

Write for additional information to:
The Wallingford Steel Co., Wallingford, Connecticut.

THE WALLINGFORD STEEL CO.

Progress in Metals for over 37 Years
WALLINGFORD, CONN., U.S.A.
COLD ROLLED STRIP: Super Metals, Stainless, Alloy
WELDED TUBES AND PIPE: Super Metals, Stainless, Alloy

For more information, turn to Reader Service card, circle No. 404

The developer says the laminate shows promise as a good thermal insulation. For example, when bonded to aluminum its low thermal conductivity (1.2 Btu/hr/sq ft/°F/in.) prevents high friction temperatures from annealing the metal underneath.

The laminate, developed in the company's research laboratory, is a modified phenol-formaldehyde resin reinforced with coventional E glass. The company is presently supplying the laminate as custom molded parts.

Coatings, Finishes for Metals, Paper, Wood

Eight new coatings and finishes are designed for the protection of metals, wood, plastics and paper.

Three coatings for paper

Three polyethylene paper coating resins have been introduced by U. S. Industrial Chemicals Co., Div. of National Distillers & Chemical Corp., 99 Park Ave., New York 16. The coating resins have been field tested and are now commercially available. They are designated Petrothene 200-2, 201-2 and 203-2. The difference between the coatings is melt index: Petrothene 200-2 has a melt index of 3.0, Petrothene 201-2 an index of 5.0, and Petrothene 203-2 an index of 8.0. All three coatings have a density of 0.915 gm per cu cm.

Four rust preventives for metals

Techline Div., Wheelbrator Corp., 2400 Avenue V, Vicksburg, Mich. is marketing four new rust preventives for use on ferrous and nonferrous metals.

Type B is recommended for use on ferrous metals. It leaves a protective film on parts being cleaned, and prevents the formation of rust on parts exposed to air and moisture.

Type G is recommended for use on aluminum.

Type D is a water-displacing chemical compound with an oil base. The compound, applied to metal parts after cleaning, displaces water and leaves a protective film on the cleaned parts.

Type S is a sprayable, water

The Olin Aluminum representative shows a customer how to ELIMINATE FAILURES ON THE FORMING LINE

PROBLEM: Customer was unable to send coil stock through progressive dies of a punch press without frequent instances of cracking and improper forming. Tried several brands of aluminum with sporadic success at best.

SOLUTION: The man from Olin Aluminum did a quick sleuthing job and decided that the press was improperly adjusted. He raised the ram several thousandths of an inch . . . increased the length of the slug removers on all punches . . . arranged to have the working area blown out every time the coil changed, for better house cleaning.

RESULT: Aluminum coil ran so successfully that the customer requested the Olin Aluminum representative to stop by to discuss speeding up the machine. Consequently, **the production rate was increased 20%. Added result:** Another steady customer for Olin Aluminum—today's fast-moving, machineable metal.

You, too, can always look to the Olin Aluminum representative for heads-up thinking. Furthermore, his keen insight into your problems is backed up by the Olin Aluminum Technical Advisory Service. Why not consider Olin Aluminum your personal storehouse of profit-building ideas.

SEE EDWARD R MURROW ON "SMALL WORLD"—EVERY SUNDAY EVENING, CBS-TV

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Applying neoprene coating *to the shell of a "gas washer." The coating must withstand abrasion and erosion caused by the flow of gas and liquids containing silt and sand.*

absorbing compound that replaces moisture left on metal parts after cleaning. The compound forms an adherent film on the surface of treated parts.

Coating for metals, wood

A general purpose, one-part neoprene rubber coating is said to have excellent resistance to chemicals, abrasion and weather. The coating, designated Coro-Gard 1706, is now available from Minnesota Mining & Mfg. Co., Adhesives, Coatings and Sealers Div., 900 Bush Ave., St. Paul 6, Minn.

The rubber coating is said to have good adhesion to unprimed steel, aluminum, copper, galvanized steel, wood, polyester-glass laminates and concrete. Also: excellent resistance to 20% hydrochloric and sulfuric acids, alkalis, and salt water at temperatures up to 120 F.

Three New Methods for Preserving Wood

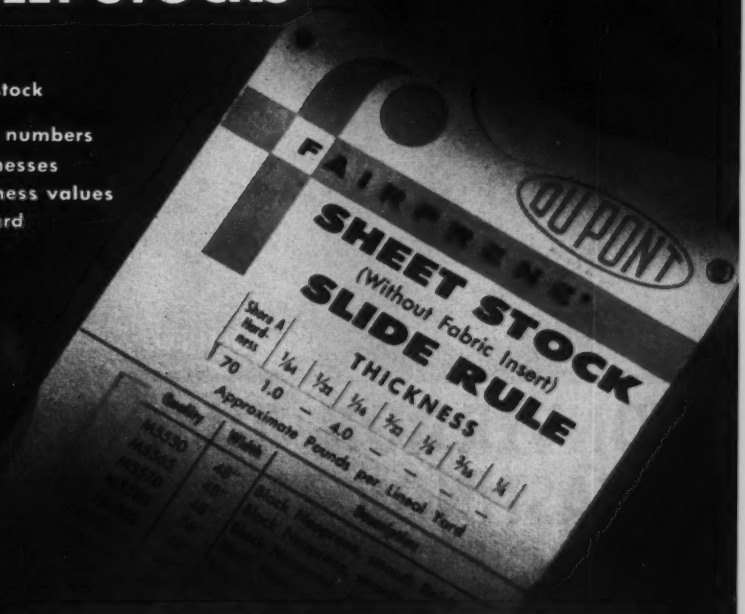
Present methods of wood preservation are based on the impregnation of wood with chemicals that are toxic to fungi, insects and marine organisms.

Recently, considerable thought and a limited amount of research has

FREE! DU PONT SLIDE CHART FOR RUBBER SHEET STOCKS

At your fingertips . . . detailed data on
23 types of Du Pont Fairprene® sheet stock

- base polymer employed • quality numbers
- colors • finishes • standard thicknesses
- widths available • Shore A hardness values
- approximate pounds per linear yard



Now in timesaving form . . . vital facts and figures on Du Pont's line of synthetic-rubber sheet stock. "Fairprene"* elastomer sheet stocks are compounded to a definite hardness for a variety of industrial applications—including gaskets, packings, tank linings. They are calendered into homogeneous sheets of standard thickness, then vulcanized and cut to specified widths. You'll find data on the one you need instantly with this new free Du Pont Slide Chart. Mail the coupon, or write E. I. du Pont de Nemours & Co. (Inc.), Fabrics Division, Dept. MDE-911, Wilmington 98, Delaware.

* Fairprene" is Du Pont's registered trademark for its coated fabrics, sheet stocks and cements.

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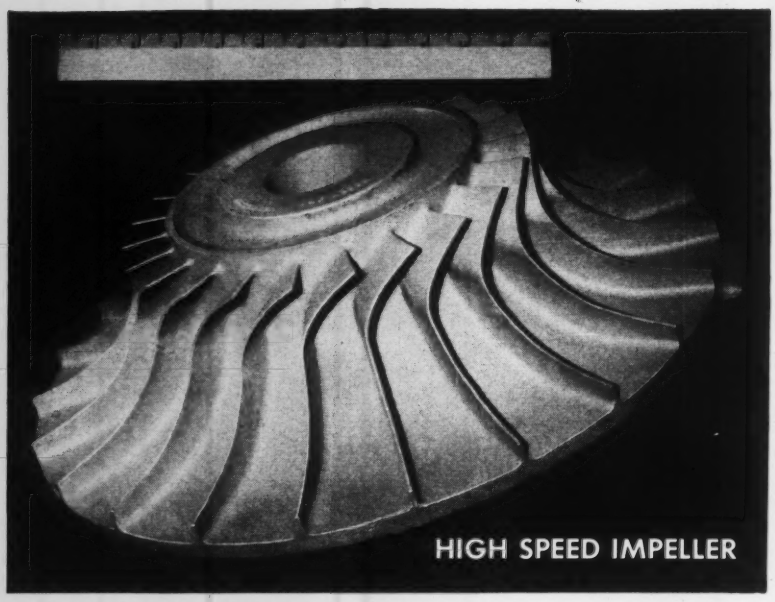
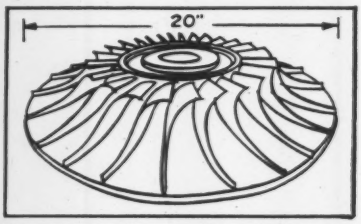


CONVERSION TO STEEL CASTINGS EFFECTED SAVINGS OF OVER 50%!

HERE'S HOW ONE MANUFACTURER SAVED OVER 50% IN PRODUCTION COSTS BY CONVERTING TO LEBANON STEEL FOUNDRY'S CERAMICAST PROCESS . . .

This Third Stage High-Speed Impeller was produced for the Carrier Corporation, Syracuse, New York. The Impeller was originally designed and manufactured as a forging, with the curved blades welded in place. Mechanical properties were good, but production costs extremely high.



Lebanon's Foundry Engineering Service solved the problem by producing the Impeller as a one piece steel casting in a unique combination of the CERAMICAST Process and other precision methods. It is now cast of Circle L 205, Grade A1-ASTM No. A-148-55, Grade 105-85. The use of a Lebanon Steel Casting has effected savings of over 50% while maintaining equal mechanical properties. During tests the Impeller attains a speed of over 12,500 rpm—held for 30 minutes.

Steel component parts now being machined, forged or fabricated can often be CAST BY LEBANON at considerable cost savings, with improved design and physical properties. Lebanon's Foundry Engineering Service will review your requirements and make specific recommendations if a conversion to steel castings can achieve lower costs for you.

DETAILED CASE HISTORIES of this and other cost saving applications, in a wide range of industries, will be sent on request. Write today for your copy.

LEBANON STEEL FOUNDRY

CARBON, LOW ALLOY AND STAINLESS STEEL CASTINGS
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been devoted to three new methods of preserving wood in which wood is treated with chemicals that are not merely deposited in the wood, but undergo reactions with the cell wall substances. One important advantage of the new methods is that the treated wood is free from toxic chemicals.

The three methods, described by R. H. Baechler in the May '59 issue of *Forest Products Journal*, are, briefly:

1. *Cyanoethylation*, which consists of treating wood with an aqueous solution of acrylonitrile and an alkali, then heating the wood. Some of the cellulose derivatives that are formed by the chemicals are not subject to dissolution by enzymes of wood-destroying fungi.

2. *Destroying thiamine* in wood. Thiamine, naturally present in wood in trace amounts, is required by wood-destroying fungi for subsistence. It appears that wood in which the thiamine content is removed would be invulnerable to attack by most fungi.

3. *Inactivating carbon, nitrogen, phosphorus, potassium* and other elements in wood with chemicals. Trace amounts of these elements are required by fungi for subsistence.

Torsional Strength of Small Diameter Wire

The behavior of small diameter spring wire can be more realistically determined from torsion fatigue tests than from conventional tensile tests now used as a standard, according to H. C. Burnett of the National Bureau of Standards.

In a recent investigation, Burnett found little correlation between the known tensile strength and the torsional fatigue properties of various straight wire specimens. In fact, an oil tempered wire showed the highest resistance to crack initiation, even though its tensile strength was the lowest of various types of wires tested.

The purpose of Burnett's investigation was twofold: 1) to determine the metallurgical factors that influence the resistance of wire to fluctuating loads, and 2) to devise a satis-

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WIRE SHAPED TO FIT YOUR DESIGN

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The shape you need • PAGE can furnish all of the standard shapes, such as squares, ovals, flats and keystones, as well as hundreds of special shapes made to your own drawings and specifications.

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PAGE shaped wire can save you money. The modern well screen is a good example. Once made by sawing slots in tubes (which clogged quickly), well screens are now made from screening formed from special shaped wire. The result is a screen with superior non-clogging features.

When you buy shaped wire, it pays to select a source with experience you can use. PAGE has been manufacturing shaped wire for more than 50 years—our know-how is your assurance of expert service. Why not ask us for a quotation?

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• For details on PAGE shaped wire, write us at Monessen, Pa., for **DH-1226.** This helpful book contains data on carbon and alloy steel weights—explains methods of calculating areas of common shapes—lists physical properties of steel wire. Also contains hardness conversion tables and standard wire gauge tables, along with other useful information.

Typical Uses for PAGE Shaped Wire

Bag frames	Generators	Screen wire
Belt buckles	Handles	Shoe buckles
Bobby pins	Hose wire	Snap rings
Business machines	Keys	Springs
Casing wire	Lamp shades	Switches
Conduits	Lock washers	Typewriters
Cotter pins	Push-Pull controls	Welding strip
Furniture hardware	Rakes	Well screens
Furniture trim	Retainer rings	Wrenches

PAGE *-the source for answers to wire problems*

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—Ni 12%—Zn 23%

WRM ALLOY A-10
ASTM Spec. B122—Alloy 3
Nom. Comp. Cu 66%
—Ni 10%—Zn24%

WRM ALLOY A-5
Nom. Comp. Cu 65% —Ni 5%—Zn Balance

WRM ALLOY B-18-S
ASTM Spec. B122—Alloy 4
Nom. Comp. Cu 55%
—Ni 18%—Zn 27%

WRM ALLOY B-12-S
ASTM Spec. B-122—Alloy 8
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What's new IN MATERIALS

***Testing machine** developed at NBS for performing reversed torsion tests on small diameter spring wire.*

factory method for evaluating this resistance. Details of the investigation are given in NBS Technical Report No. 2299.

What tests showed

Tests were performed on three different types of wire: 1) a cold drawn music wire, 2) an oil tempered music wire, and 3) a wire fabricated from a special heat of vacuum melted steel. The carbon contents of all three wires ranged from 0.86 to 0.89%. The wires were all drawn to 0.039-in. dia.

Two fatigue testing machines were used: one for testing springs, the other for testing straight wire specimens. Curves showing stress vs cycles-to-cracking were derived from test results. The curves indicated that:

1. Fatigue life of springs coiled from vacuum melted wire was about twice that of springs made from cold drawn music wire. The difference in fatigue life was probably caused by the greater cleanliness of the vacuum melted material.

2. Fatigue life of springs made from oil tempered wire showed a fivefold increase over that of the cold drawn wire.

Burnett says that cold drawn wire has poorer fatigue life because the material has a highly cold worked structure in which grains are fragmented and elongated along the axis of the wire, providing longitudinal planes that are inherently weak. When the wire is stressed in torsion,

A new family of materials to meet special problems

•

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Each has particular advantages for specific service requirements, involving various combinations of impact, stress and wear. Check the brief facts on these alloys below. Then call in an Amsco sales engineer to assist in selecting the *one best* material to meet your application needs.

AMSCO ALLOY DESIGNATION	DESCRIPTION AND USES	MECHANICAL PROPERTIES
MY	Heat-treated, chromium alloyed manganese steel... for use in light-to-medium weight castings requiring modest improvement in growth and distortion, and increased stiffness.	tensile strength ..... 120,000 psi yield strength ..... 56,000 psi elongation ..... 45% reduction of area 30%
MML	Heat-treated, molybdenum alloyed manganese steel... for castings requiring improved weldability, for extremely heavy metal sections, and castings exposed to excessive heating environments.	tensile strength ..... 120,000 psi yield strength ..... 52,000 psi elongation ..... 50% reduction of area 40%
MMH	Heat-treated, molybdenum alloyed manganese steel... for use in castings requiring optimum mechanical properties and wear resistance. Provides improved stiffness and resistance to peening and flow.	tensile strength ..... 120,000 psi yield strength ..... 65,000 psi elongation ..... 20% reduction of area 18%
CML	Heat-treated, air-hardening chrome-moly steel... for casting applications involving scouring or grinding wear. Suitable for more complex casting designs.	tensile strength ..... 155,000 psi yield strength ..... 130,000 psi elongation ..... 10% reduction of area ..... 15% hardness ..... 275-375 BHN
CMH	Heat-treated, air-hardening chrome-moly steel... exhibits potentially improved wear resistance over CML (above), when shock loading is not sufficiently severe to cause breakage.	tensile strength ..... 155,000 psi yield strength ..... 130,000 psi elongation ..... 6% reduction of area ..... 7% hardness ..... 300-400 BHN
CS	Martensitic, multiple alloy steel with chromium, nickel and molybdenum... combines high mechanical strength with good abrasion and wear resistance.	tensile strength ..... 220,000 psi yield strength ..... 195,000 psi elongation ..... 8% reduction of area ..... 20% hardness ..... 300-500 BHN
HC	High chromium cast iron... provides outstanding abrasive wear resistance, where impact force is low but particle velocity and scouring forces are high.	tensile strength ..... 60,000 psi transverse strength ..... 7,000 lbs. deflection ..... 0.12 in. hardness ..... 400-600 BHN

For further Information
—write for technical bulletin on "Amsco Ferrous Alloy Castings".

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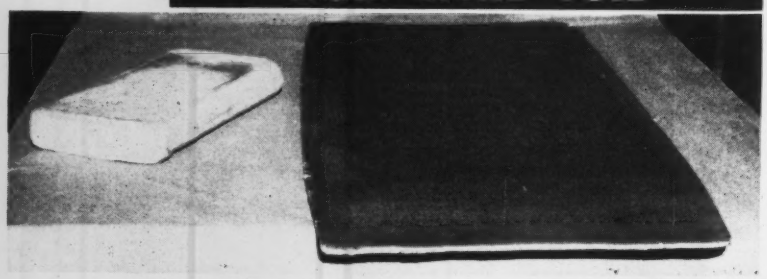

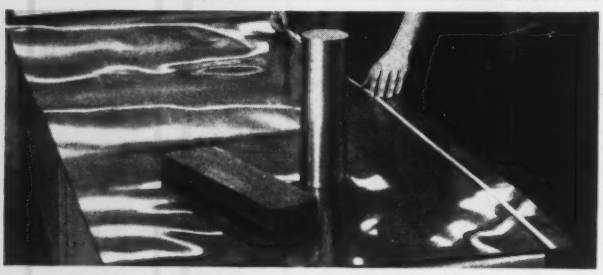

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these planes lie parallel to a plane of maximum shear stress and afford avenues by which longitudinal fatigue cracks can easily propagate.

In contrast, the oil tempered wire has relatively uniform grains of tempered martensite. As recrystallization takes place, the inherent planes of weakness are removed, and the grains are more resistant to torsional fatigue stressing.

Effects of shot peening

Burnett also investigated the effects of shot peening on the mechanical properties of springs. He found that shot peening significantly increased the fatigue life of springs and straight wire specimens when stressed in torsion. Shot peening seems to reduce the effect of any single stress raiser caused by die marks or imperfections formed during wire fabrication.

Alloying Columbium for Oxidation Resistance

The oxidation rate of columbium in slowly flowing air at 2000 F can be reduced by a factor of 20 by adding cerium, chromium, titanium and aluminum to the metal. But such improvement falls short of the factor of 100 generally agreed to be a prerequisite for the use of columbium-base materials in air at 2000 F.

This finding is one result of work done by E. C. Hirakis of Horizons Inc. aimed at improving the oxidation resistance of columbium at 2000 F by alloying, and at 2500 F by metallizing or electroplating.

Hirakis, who described his work in OTS Report No. PB 151684, says that specimens produced by both metallizing and electroplating equalled or surpassed the minimum standard of 4 to 6 hr for coated columbium at 2500 F. However, all

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efforts to repeat these results failed. He believes more elaborate metallizing equipment may turn out coated specimens giving consistent results.

With respect to electroplating, Hirakis says a research program aimed at the development of a preplating cycle capable of inducing strong as-plated adhesion between electrodeposits and the columbium base metal would significantly improve the reliability of electroplating as a coating method.

Cold Weather Tests for Plastics, Metals

Cold weather testing of metals, plastics, adhesives, rubber, textiles, coatings, paints, barrier papers, insulation, leather, fuels and lubricants is offered by Gorham Laboratories Inc., Gorham, Me. The research organization maintains testing facilities atop Mt. Washington in New Hampshire.

The mountain top offers weather conditions of extreme cold, heavy winds, icing and general arctic weather. It has an annual average temperature of 27.1 F and an average annual snowfall of 177 in.

Copper-Nickel Alloy Usable at 850-900 F

A new 70:30 copper-nickel alloy for heat exchanger tubes is said to have the proper combination of strength, ductility and stress corrosion resistance to make it suitable for unfired pressure vessel use at temperatures up to 850-900 F.

This is the conclusion derived from physical, mechanical and creep tests performed on a wrought copper-nickel alloy called Cufenloy 30. The results of physical and mechanical tests, as well as creep tests, are given in the two accompanying tables.

The new alloy was developed by

This article is based on a paper by W. F. Simmons (High-Temperature Metals Research Div., Battelle Memorial Institute), B. J. Sirois (Phelps Dodge Copper Products Corp.), D. N. Williams and R. I. Jaffee (Nonferrous Physical Metallurgy Div., Battelle Memorial Institute). The paper was presented at the 62nd annual meeting of the ASTM, June '59.

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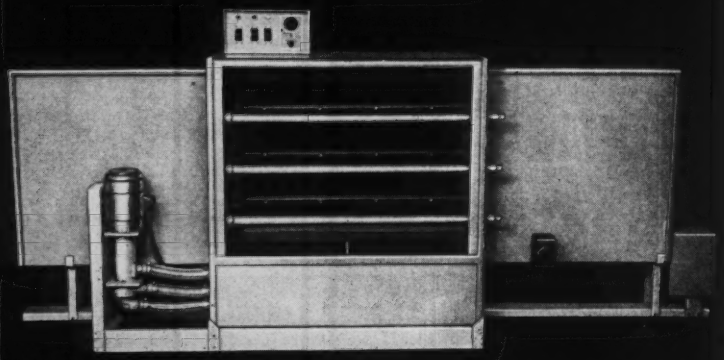

Production Etcher for Printed Circuits, made by Centre Circuits, Inc., State College, Pa.

To resist acid corrosion, this etcher is primarily made of Van-Cor PVC pipe, fittings, (standard and specially machined), valves, sheet (transparent and regular), and joining strips.

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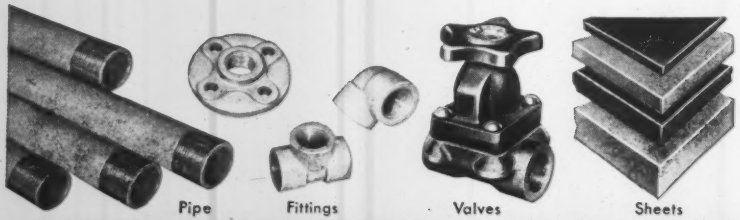

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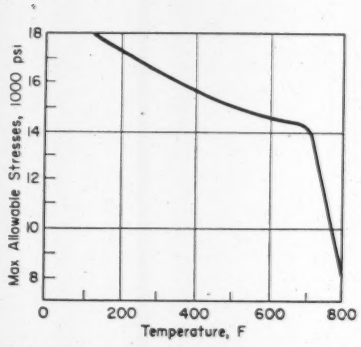
What's new IN MATERIALS



ASME stress values *for new 70:30 copper-nickel alloy.*

Phelps Dodge Copper Products Corp., 2010 N. 10th St., Philadelphia 22. It is available in limited quantities.

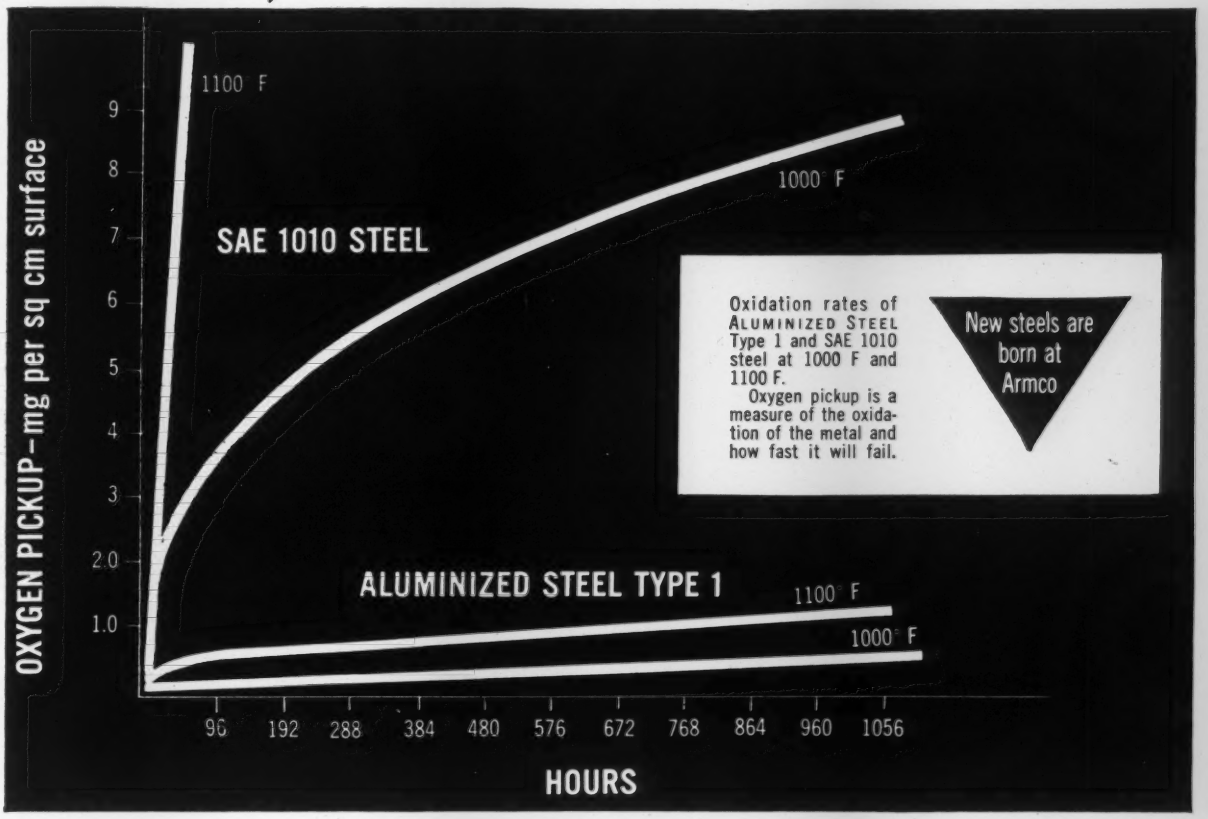
ASME special ruling

Just recently, the Boiler and Pressure Vessel Committee of the American Society of Mechanical Engineers issued Case No. 1266 (Special Rul-

PROPERTIES OF CUFENLOY 30

NOMINAL COMPOSITION, %	Cu 70, Ni 29.1, Fe 0.5, Mn 0.35
PHYSICAL PROPERTIES	
Coef of Ther Exp, per °F	
68-200 F	8.7×10^{-6}
68-750 F	9.4×10^{-6}
Ther Cond, Btu/hr/sq ft/°F/ft	
68 F	16.8
572 F	22.0
Elec Res, microhm-cm	
68 F	36.3
572 F	37.6
Elec Cond, megmho-cm[a]	
68 F	0.0276
572 F	0.0266
Dynamic Mod of Elast, 10^6 psi	
80 F	20.9
800 F	18.8
MECHANICAL PROPERTIES[b]	
Ten Str, 1000 psi	
75 F	77
700 F	62
1050 F	43
Yld Str (0.5% ext), 1000 psi	
75 F	61
700 F	19
1050 F	16
Red. in Area, %	
75 F	58
700 F	62
1050 F	48

[a]Megmho-cm = (microhm-cm)$^{-1}$.
[b]Tests performed on drawn and stress relieved specimens.



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Comparative oxidation rates indicate remarkable durability of corrosion-resistant Armco ALUMINIZED STEEL Type 1 at high temperatures.

Oxidation rates of ALUMINIZED STEEL Type 1 at 1000 and 1100 F compared with those of SAE 1010 steel demonstrate why this special Armco Steel has become a popular material for parts that must resist heat.

The hot-dip aluminum coating applied by a special Armco-developed process prevents oxygen from destructively scaling the base metal at temperatures up to about 1250 F. In addition, ALUMINIZED STEEL also provides good corrosion resistance. This unique combination of steel and aluminum withstands the corrosive attack of combustion products and condensates.

Because ALUMINIZED STEEL Type 1 combats both heat and corrosion and because its steel base gives parts high strength, it can be used in thinner gages and at higher temperatures than other metals.

For these reasons, Armco's special aluminum-coated steel has proved to be the most economical and durable metal for auto mufflers, heat exchangers, combustion chambers, industrial ovens, appliances, and similar products requiring resistance to heat and corrosion. Put the cost-cutting, performance-improving advantages of Armco ALUMINIZED STEEL Type 1 to work in your products. Write us for complete information. Armco Steel Corporation, 3249 Curtis Street, Middletown, Ohio.

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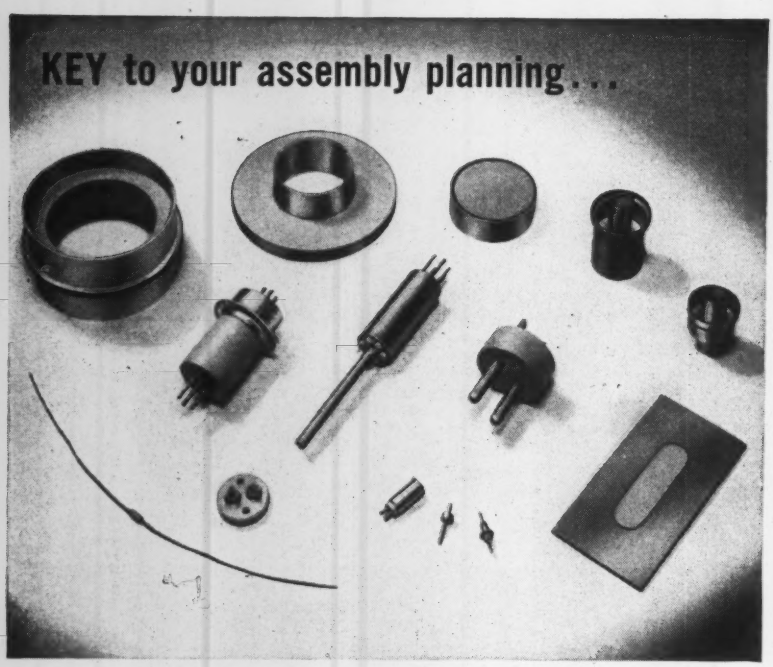

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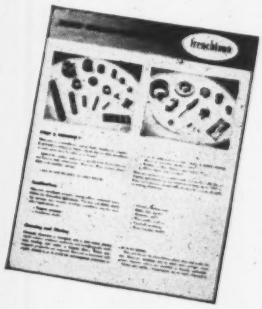
. . . permits excellent dimensional control.

. . . offers high bond strength.

MOLCOTE surfaces are supplied ready for use for soldering and brazing applications in any temperature range up to 2000° F. MOLCOTE bonds are exceptionally strong with a tensile strength exceeding 10,000 psi.

Frenchtown Engineering Bulletin 1155 contains complete details and data on MOLCOTE Metallized Coating for Ceramics. We'd be pleased to send you a copy for use in your assembly planning. A good time to write for it is *NOW*.



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CREEP PROPERTIES OF CUFENLOY 30

Stress, 1000 psi[a]	Min Creep Rate, %/hr	Initial Deformation, %	Total Deformation (500 hr), %
500 F			
60 (342.7 hr)	0.000017	2.209	–
50 (282.1 hr)	0.00030	0.342	–
40 (214.9 hr)	Nil	0.225	–
750 F			
40 (1391.3 hr)	0.00040	0.274	0.620
35 (933.4 hr)	0.00017	0.214	0.391
30 (1367.9 hr)	0.000055	0.175	0.302
25 (2351.8 hr)	0.000032	0.153	0.241
18 (2516.5 hr)	0.000015	0.118	0.176
950 F			
6 (1104.3 hr)	0.00018	0.042	0.204
2 (1491.2 hr)	0.000032	0.018	0.061
1000 F			
1.5 (746.9 hr)	0.0003	0.015	0.185

[a]Times at which specimens are tested are given in parentheses.

ing) approving maximum allowable stress values for Cufenloy 30 copper-nickel alloy at temperatures up to 800 F.

The special ruling specifies a maximum allowable stress of 14,400 psi at 750 F and 8000 psi at 800 F. Other stress values are given in an accompanying graph.

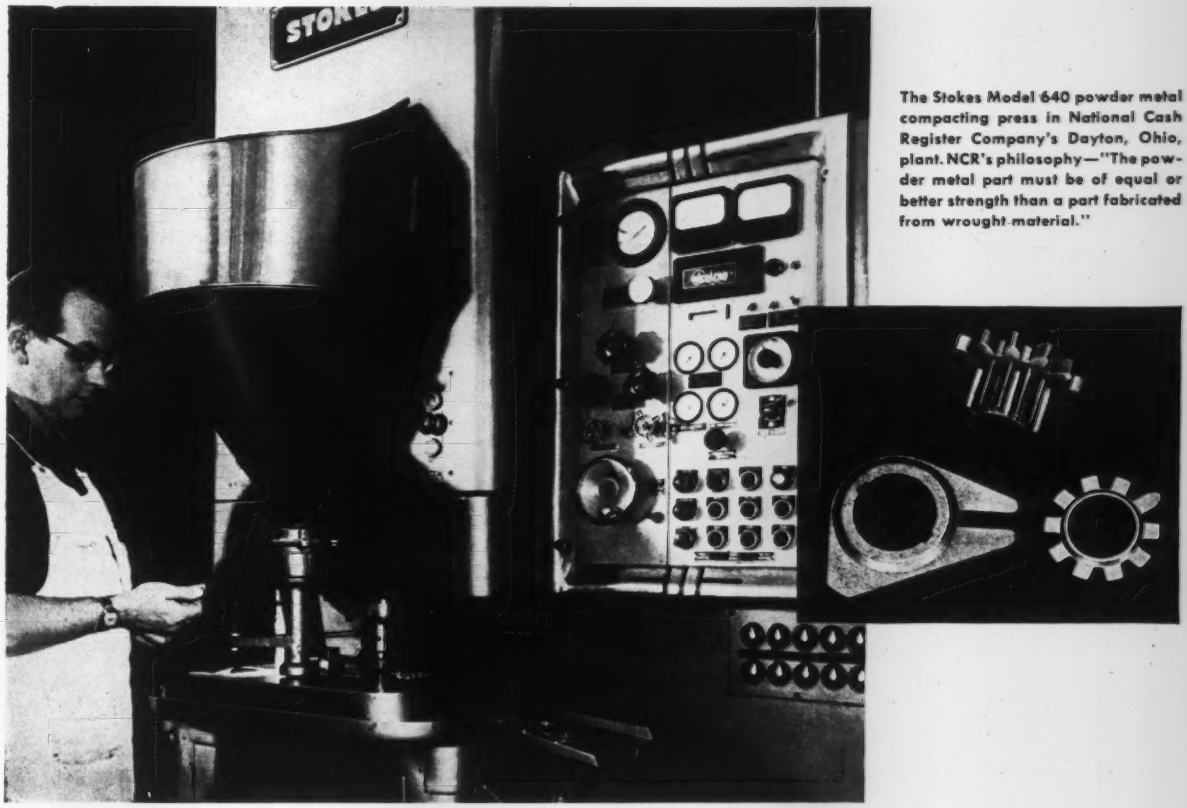
The special ruling also specifies a minimum tensile strength of 72,000 psi, a minimum yield strength (0.5% ext under load) of 50,000 psi and a minimum elongation (in 2 in.) of 20%. Other properties given in the ruling conform to ASTM B-111 for copper and copper alloy seamless condenser tubes and ferrule stock.

Why tests were performed

Tests were performed on Cufenloy 30 copper-nickel alloy because design factors for annealed copper-nickel condenser tubes have been based chiefly on creep data contained in reports made in 1942 (by Burghoff, Blank and Maddigan), in 1947 (by Burghoff and Blank), and in 1954 (by Port and Blank).

The data in these reports are said to have limited copper-nickel alloy condenser tubes to uses and designs that fail to take full advantage of the higher mechanical properties obtainable with Cufenloy 30.

(more What's New on p 182)



The Stokes Model 640 powder metal compacting press in National Cash Register Company's Dayton, Ohio, plant. NCR's philosophy—"The powder metal part must be of equal or better strength than a part fabricated from wrought material."

National Cash Register rings up savings through powder metallurgy...

The Stokes Model 640 50-ton powder metal press, at the Dayton, Ohio, plant of National Cash Register Company, has proved a valuable tool in the production of precision gears and parts for cash registers and accounting machines. In 1957, over 250 different high-density parts were made by powder metallurgy—in early '58, 47 additional parts went into production.

The economic benefits of this process have also been proved. A cost analysis of 54 parts shows substantial savings per year through lower direct labor costs in machining and inspection. More complex parts are continually being introduced—parts with hubs, steps, and thin projections—made possible by press equipment such as the Stokes 640.

The Stokes Model 640 offers up to five press motions with independently adjustable compression, fill and ejection points . . . each with direct reading position indicators calibrated to .001". This set-up versatility is teamed with operating simplicity that enables economical long or short runs, and permits easy re-runs of jobs on which set-up standards have been established.

Investigate the proved potential of powder metal pressing . . . not only for ways to cut costs and save metal over conventional machining, but also for ways to get properties of metals, alloys and mixtures not attainable by other techniques. Ask for a production and economic analysis on your own parts. Stokes' facilities include sample production, punch and die design and fabrication, and operator instruction. Stokes Engineering Advisory Service is ready to serve your powder metallurgy needs, whether large or small.

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F. J. STOKES CORPORATION
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STOKES

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Oxidation and thermal shock resistance of metals used in jet engines and similar superheat applications are greatly improved with CHROMALLIZING. The patented and proven process of diffusing chromium with other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake; the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes.

Alloy	Usual Operating Temperature	Operating Temperature of CHROMALLIZED Alloy
Iron Base (including stainless steels)	1500° F	SA CHROMALLIZED 310 and 321 stainless steels show no failure after 18 hours at 1950° F in an atmosphere containing lead bromide and lead sulfide.
Nickel Base	1800° F	U CHROMALLIZED nickel base alloys are unattacked after 200 hours at 2000° F.
Cobalt Base	1800° F	SAC CHROMALLIZED cobalt base alloys are unattacked after 150 hours at 2200° F.
Molybdenum	Over 2000° F	W-2 CHROMALLIZED molybdenum shows no failure after 400 hours at 2350° F, after 48 minutes at 2800° F, and after one minute at 3400° F.

IOCHROME, a recent Chromalloy development, is a super pure chromium metal that can be used as a basis for chromium alloys for use at 2500°F. Until now, such alloys were not practical because of their lack of room temperature ductility.

Ordinary steel can also be chromallized to provide resistance to corrosion, oxidation and wear.

Chromalloy corporation

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For more information, turn to Reader Service card, circle No. 400

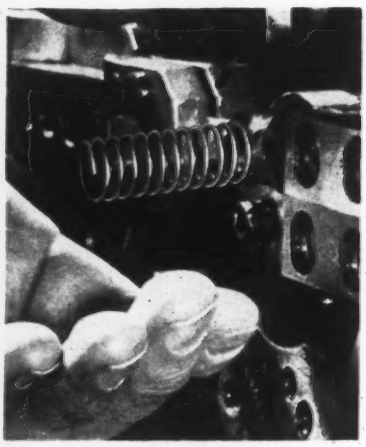
What's new IN MATERIALS

Urethane Laminate Has High Flexural Strength

An experimental polyurethane-glass laminate has strength properties exceeding those required by government specifications for polyester, epoxy and phenolic-glass laminates.

For example, a 0.092-in. thick urethane-glass laminate has a flexural strength of 90,000 psi, as compared with 50,000 psi for a 0.125-in. thick polyester-glass laminate meeting government specification MIL-R-7575A.

The new laminate came out of work done by Angelo P. Bonanni of the Naval Air Material Center, Aeronautical Materials Laboratory, Philadelphia 12. Bonanni says the polyurethane-glass laminate may eventually find use in such missile



Heat resistant spring—The spring shown here coming out of a coiling machine is made of a new cobalt-base alloy developed by National-Standard Co., Howard & 8th Sts., Niles, Mich. The developer says springs made of the alloy can be used at temperatures from 400 to 1400 F. The superalloy, designated HS 25, contains 46 to 53% cobalt, 19 to 21% chromium, 14 to 16% tungsten, 9 to 11% nickel and 0.05 to 0.15% carbon. Wire drawn to a 30% reduction from the alloy has a tensile strength from 200,000 to 240,000 psi and an elongation from 4 to 8%.

EXTENSIVE DOW PRODUCTION FACILITIES FASHION VARIED NEW MAGNESIUM WARES

Coiled sheet, thin wall castings, many other production items are now available from Dow's big rolling mill, foundry and fabrication facilities.

Manufacturers on the alert for improved materials and production methods would enjoy a quick tour of the four Dow plants that turn out magnesium products. New ways of forming and fabricating magnesium now being practiced in these plants open up new areas of use for the lightweight metal.

TOOLING PLATE, extra flat, is annealed to eliminate residual stresses.

At the huge Madison, Illinois, rolling mill, for example, they're making magnesium sheet that doesn't require stress relief after welding. This is a major step forward in light metal technology and a boon to manufacturers using magnesium assemblies. Madison has also increased the maximum width of sheet to six feet. Five different sheet alloys, including elevated temperature alloys, are now available either flat or in coils.

To keep abreast of the rapidly increasing demand for precision jigs and fixtures, Madison keeps a close watch on the tolerances of Dow magnesium tooling plate. Typical flatness tolerances, for example, are 0.010 inches in any six feet. This means greater accuracy and less machining for users of Dow tooling plate. A mammoth 13,200 ton extrusion press, also located at Madison, is now turning out magnesium extrusions up to 30-inch circumscribed circle in size.

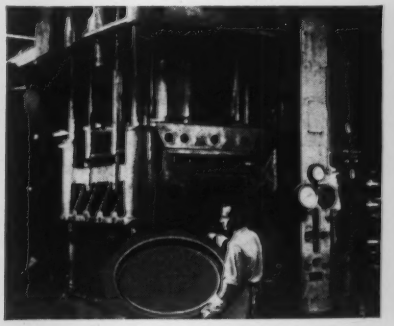
Over in Bay City, Michigan, interesting things are happening, too. At the well-equipped Dow magnesium foundry, largest in the U. S., sand and permanent mold castings of all sizes and shapes are being produced on a volume basis. Complete facilities are maintained for heat treatment, styrene DMI impregnation and chemical treatment. A well-staffed quality control team makes sure that all specifications are met or exceeded, and that the most modern equipment and techniques are fully utilized.

The Bay City foundry casts many complex and difficult designs. Large castings with walls as thin as 0.100 are now being produced. Other useful developments include cast-in tubeless passageways for use as hydraulic lines, special coring techniques for casting enclosed shapes and new magnesium casting alloys.

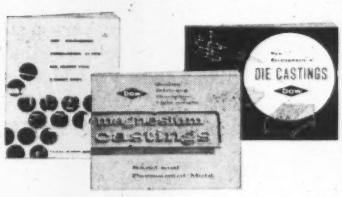
A new die casting plant is now on stream at Bay City. This facility houses the most advanced magnesium die casting equipment, including cold chamber metering units which automatically feed metal to the machines and contribute to unusually high production rates. To assure close alloy composition control in both die casting plant and foundry, a direct reading spectrometer provides frequent and precise analyses of the molten metal. Similarly, X-ray equipment is also available where radiography is needed in quality control.

The Dow fabrication plant, also in Bay City, offers capacity for volume work on magnesium assemblies. Here, too, developmental work on magnesium is constantly in progress. The plant is set up to handle large or small jobs, and plenty of both. Its activities include deep drawing, bending, spinning, stamping, piercing, machining, arc and spot welding, assembly, chemical treatment and painting. This plant has pioneered many "firsts" in magnesium production, such as hot drawing, spot welding and automatic welding.

DOW FOUNDRY offers production capacity for sand and permanent mold castings of all sizes.



LARGE DRAW PRESS at Dow's fabrication plant forms magnesium sheet in one operation.



WRITE TODAY for more information about Dow's magnesium production facilities. Request "Fabrication Brochure", "Foundry Brochure", "Die Casting Brochure" or all three. THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Sales Department 1351CD11.

DOW

THE DOW METAL PRODUCTS COMPANY
Midland, Michigan
Division of The Dow Chemical Company

For more information, turn to Reader Service card, circle No. 385

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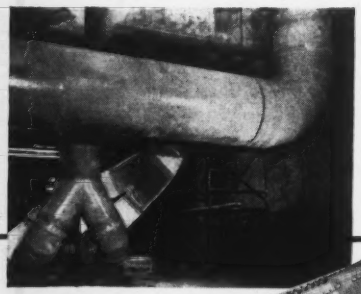

in the
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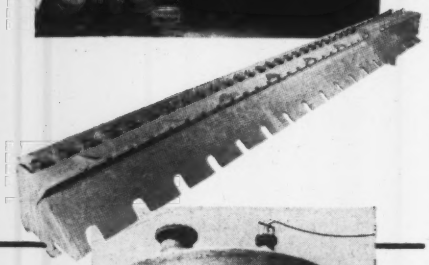
industry

Complex rayon spin machines, feed pipes, filters, screens, tanks and similar equipment are fabricated from Duracor.



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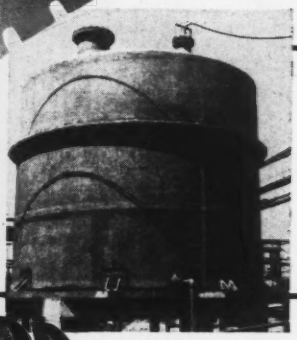
industry

Acid storage tanks, tank trailers, exhaust systems, pressure pipes and other Duracor products are rendering outstanding service.



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Duracor is used extensively for special processing equipment, processing tanks, laboratory sinks, brine tanks, acid storage tanks, covers and ventilating systems.

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Tensile Strength p.s.i.: 11,000-15,000

Flexural Strength p.s.i.: 20,000-30,000

Tensile Modulus of Elasticity p.s.i.: 1.2—1.4 x 10^6

Flexural Modulus of Elasticity p.s.i.: 0.78—1.6 x 10^6

Impact Izod, Notched ft.-lbs./in.: 30—40

Specific Gravity: 1.4

Coefficient of Linear Expansion: 9.5 x 10^{-6} in./in./°F.

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FLEXURAL STRENGTH OF LAMINATES COMPARED

Laminate	Mil Spec	Flex Str, psi
Urethane[a]	—	90,000
Polyester[b]	MIL-R-7575A	50,000
Epoxy[b]	MIL-R-9300	70,000
Phenolic[b]	MIL-R-9299	50,000

[a]Tests performed on 0.092-in. thick specimens.
[b]Tests performed on 0.125-in. thick specimens.

parts as radomes, rudder and fin tips, and fuel cell backing boards.

How laminate was made

1. Glass fabrics were immersed in a newly developed polyurethane resin and laid up at 90 deg to one another.

2. The layup was wrapped in a sheet of cellophane and placed between two highly polished and heated chromium-plated steel platens.

3. The entire assembly was then subjected to a load of 1100 psi in a molding press. After a specified time, the load was reduced so that the laminating assembly remained in a fixed position under a very slight load. The laminate was allowed to cool under these conditions, and then was removed from the assembly.

Creep, Tensile Data on Sand Cast Aluminum

by D. K. Fox and W. J. Reichenecker*

The graphs and tables on the following pages show 1) creep characteristics and 2) tensile properties of the principal aluminum sand casting alloys at moderately elevated temperatures.

A previous study showed the impact resistance and fatigue characterestics of these alloys in graphical and tabular form (see M/DE, Oct '58, p 103).

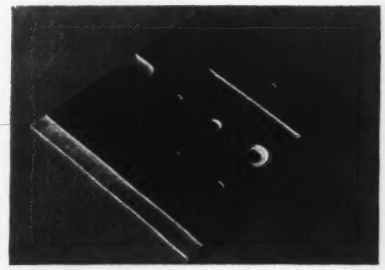
1. Creep characteristics

The results of creep-rupture tests performed at 480 F indicate that creep is not likely to be a problem in these aluminum sand casting alloys at moderately elevated temperatures

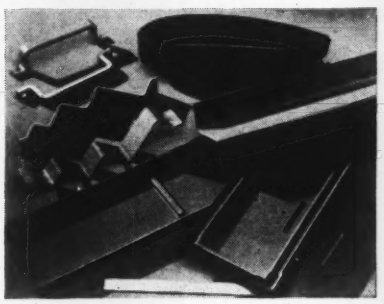
* The authors are associated with the Materials Engineering Dept. of Westinghouse Electric Corp., East Pittsburgh, Pa.

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **Fire-retardant electrical laminates**
- **Plastic for wire-spring relay**



Plain . . .



or fancy

This electrical laminate deserves more than a casual look, if only because there are so many things you can do with it.

Made of glass-reinforced polyester, it comes in sheets or molded shapes that embody three useful attributes. First, they are strong enough to play a structural role in heavy-duty electrical equipment. Second, they retard fire. Third, their excellent electrical properties change but little at 100% relative humidity.

The shapes you see here are made with Hetron® polyester resin by Fiber Glass Industries, Inc., and are inherently flame-retardant. Hetron burns only in the immediate vicinity of an arc or hot flame, and quickly extinguishes itself when the heat source is removed. Thus in case of a burnout, damage is usually confined to a small area, with minimum effect on mechanical strength of the material.

Generally, Hetron laminates exhibit very low loss factor over a wide range of frequencies. Dielectric constant, for a ⅛-inch glass-mat laminate containing 35% glass, hovers as low as 4.25. Arc resistance of such a laminate is on the order of 110 seconds.

Do these traits suggest a way to achieve long life in equipment handling medium and high voltages? We'll gladly send you the complete data file on Hetron resins, and names of skilled fabricators who can supply laminates and molded shapes to match your ideas.

Building a better relay

Often it isn't enough to design a product. You may also have to find a way to make it.

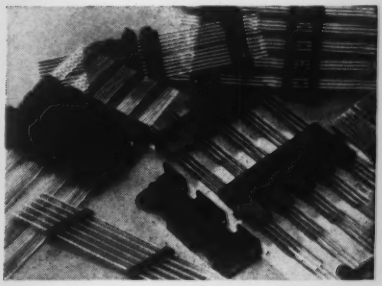
Such was the case when engineers at Bell Telephone Laboratories developed for Western Electric Co. a new relay, basic component of telephone switching equipment.

In one swoop the new design—called the wire-spring relay—promised to reduce manufacturing and maintenance costs, work better, and last longer than its predecessor. However, this involved something that had never been done—molding straight wires into small plastic blocks automatically.

Before it could be done, Western Electric engineers had to:

1. devise a way to straighten small-diameter spooled wire;
2. feed the straightened wire into a mold in precisely spaced groupings;
3. embed the wires without shift in a molding compound that would insulate them and hold them securely for a relay lifetime of one billion operations or more.

Early in the game it became apparent that this was a job for phenolics. A major requirement was fast cure. Another was batch-to-batch consistency of the molding material. At fast cure speeds, a 10% variation in curing time can mean as little as 1.2 seconds' leeway between a reject and a good piece.



Volume resistivity was important. Could a Durez material handle the job?

Yes, one could. The wire-spring subassemblies you see here are made with it. They are being produced at low cost to the required accuracy in fully automatic molding machines. They prove the ingenuity of the men who developed this new concept in telephone switching—and the versatility that *you* command when you design with Durez materials.

To get a better idea of how far this versatility goes, check the coupon for more information. Booklets are available describing a range of properties you can get from typical Durez materials; give helpful suggestions on where to use them.

For more information on Durez materials mentioned above, check here:

- ☐ Data on Hetron, including fabricator lists (50-A)
- ☐ Durez molding compounds (14 page booklet)
- ☐ General information on Durez Products (Bulletin 400)

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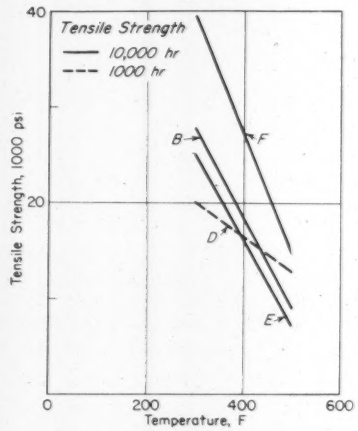
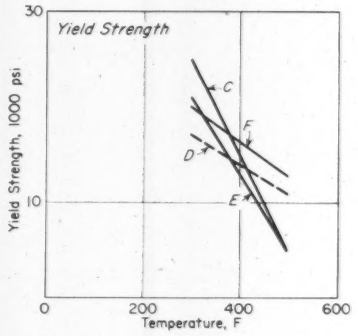
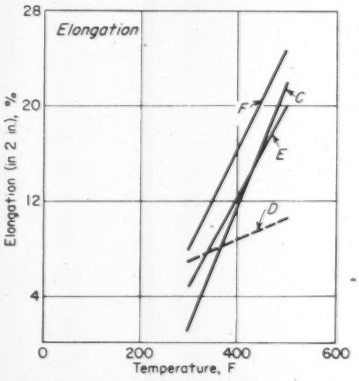
unless stress levels are unusually high. This is epecially true for alloys B and C which have sufficient creep resistance at 480 F to make them useful for short-time applications. Alloy C (SC51A) had the best creep







***Tensile properties** of several aluminum alloys at elevated temperatures after 1000 and 10,000 hr exposure. (From published literature.)*

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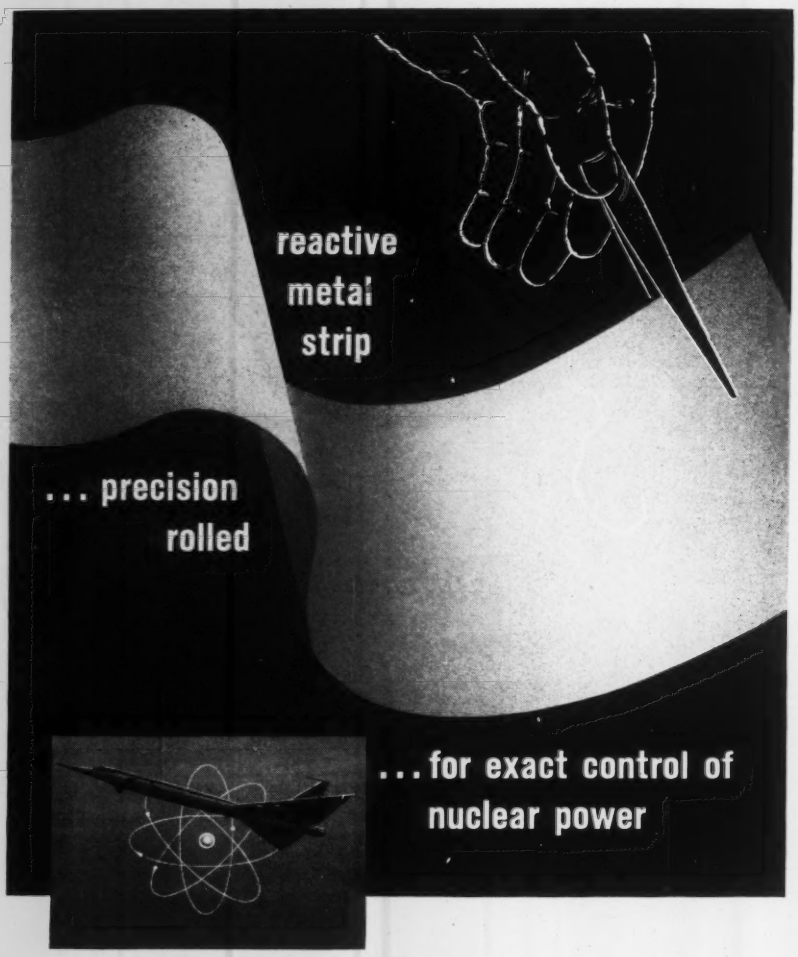

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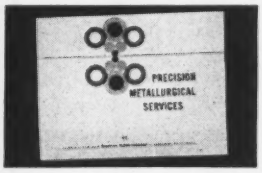


HAMILTON
WATCH COMPANY / **Precision Metals Division**
Lancaster, Pennsylvania

For more information, turn to Reader Service card, circle No. 379

What's new IN MATERIALS

resistance under all test conditions.

2. Elevated temperature tensile properties

At 500 F, the alloys generally behaved as expected, in that tensile and yield strengths decreased with increasing temperature for a given exposure time. As exposure time increased there was a further decrease in strength for all alloys. In most cases the elongation of the alloys increased with increasing temperatures and exposure times.

Tests show that the effect of exposure time is undoubtedly related

COMPOSITION OF ALLOYS

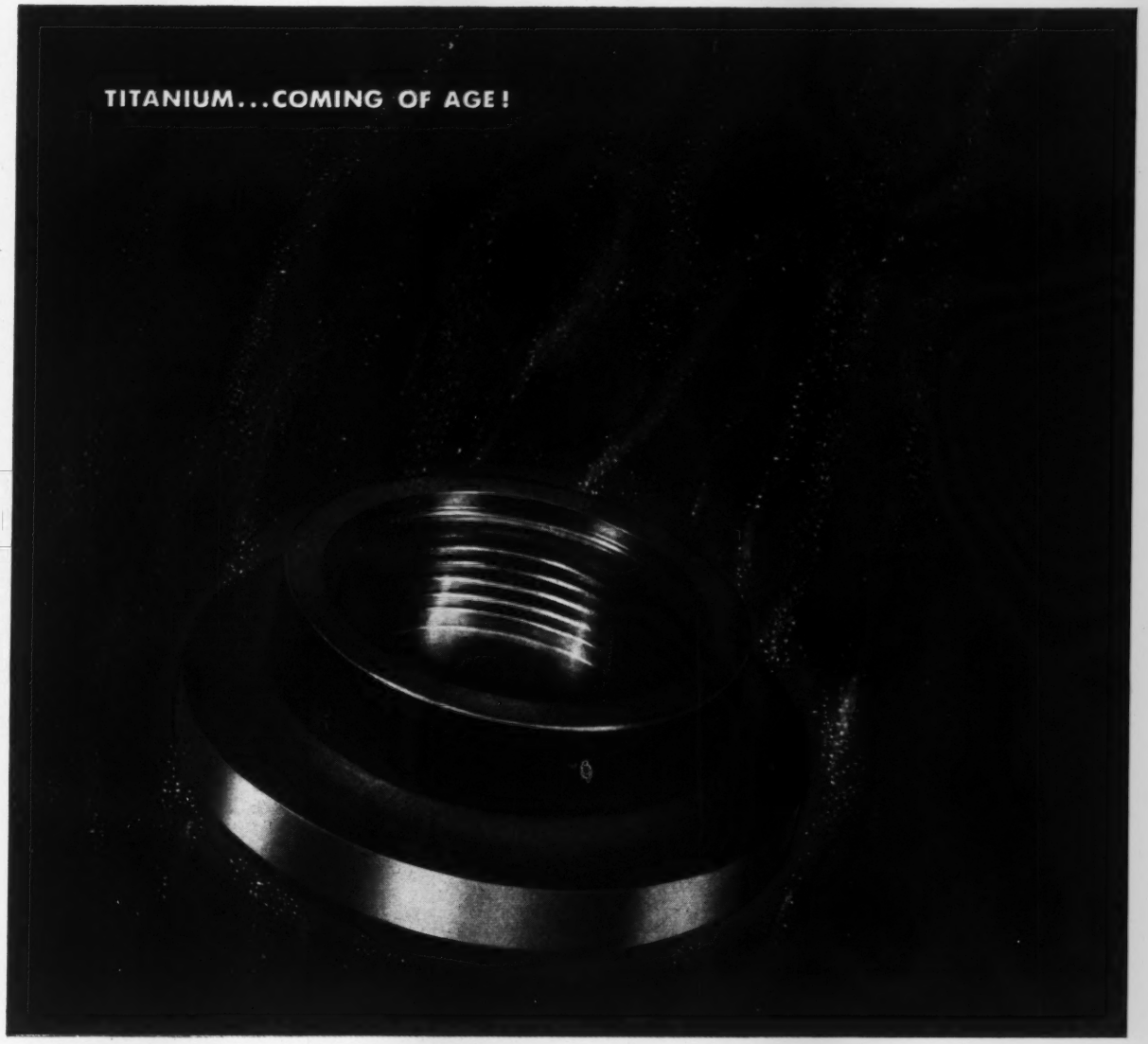
Alloy[a]	ASTM No.[b]	Composition, %[c]
A	—	6.5 Mg
B	C4A	4.5 Cu-1.5 Si
C	SC51A	5.0 Si-1.25 Cu-0.5 Mg
D	ZG61A	5.6 Zn-0.6 Mg-0.5 Cr-0.2 Ti
E	SG70A	7.0 Si-0.3 Mg
F	G10A	10.0 Mg

[a]These labels are arbitrary, adopted for convenience in this article.
[b]All alloys included in ASTM B26-56T except alloy A.
[c]Balance aluminum.

MECHANICAL PROPERTIES OF ALLOYS A, B, C, D, E AND F

Alloy →	Room Temp	300 F[a]	480 F[a]
TENSILE STRENGTH, 1000 PSI			
A	38	32	21
B	40	35	34
C	36	33	28
D	42	27	14
E	37	29	20
F	51	40	28
YIELD STRENGTH, 1000 PSI			
A	19	19	17
B	28	27	26
C	27	27	27
D	30	18	12
E	28	25	30
F	39	27	24
ELONGATION (IN 2 IN.), %			
A	14.5	16.0	11.0
B	4.0	3.5	2.5
C	3.2	2.5	1.5
D	5.7	7.0	12.5
E	3.5	3.4	2.5
F	13.0	22.0	13.0

[a]20 min exposure.



Titanium powder now economically formed into strong, lightweight, corrosion-resisting parts

Titanium has entered still another fabricating field . . . powder metallurgy . . . that adds to its growing usefulness in the chemical, processing, and other industries.

Today you can design titanium parts to be formed by powder metallurgy techniques that combine strength, purity and corrosion resistance equal to wrought titanium. Close tolerances permit a minimum of machining on contacting surfaces; none on non-contacting surfaces. An example is the chemical valve seat, above, made by Clevite Corporation of Cleveland, Ohio.

Finished parts weighing from less than an ounce up to many pounds are being produced. Shape can range from simple gear or cam blanks to complex pieces with wide variation in cross-section. Titanium powder metal parts compare favorably in cost with wrought and machined parts.

To learn more about the growing use of titanium powder metallurgy for corrosion-resisting, light, strong parts, write us. Union Carbide Metals Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Union Carbide Canada Limited, Toronto.

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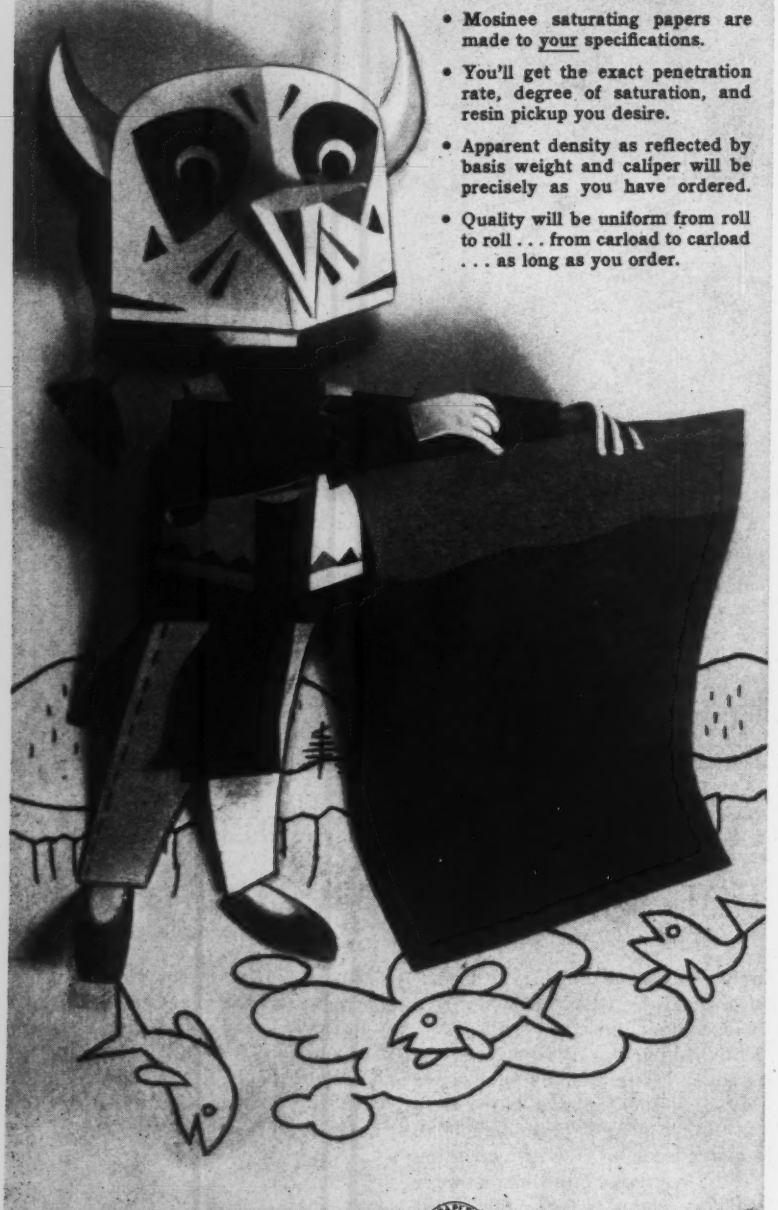

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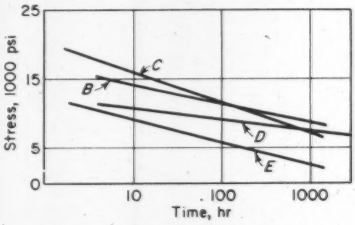


***Creep-rupture properties** of aluminum casting alloys B, C, D and F at 500 F.*

to the precipitation hardening characteristics of these alloys which are normally aged in the temperature range of 300 to 480 F.

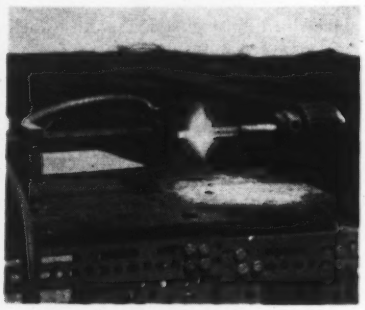
The elevated temperature tensile data given for aluminum sand casting alloys B, C, E and F on the graphs were obtained from published technical literature.

Heat Shield Material for Rocket Nose Cones

A heat shield material for missile and rocket nose cones has been developed by General Electric Co.'s Missile and Space Vehicle Dept., 3198 Chestnut St., Philadelphia 4. The material, described as an "organic plastics substance," can be fabricated into heat shields in a short time compared to the weeks-long production schedule for current nose cone protectors.

How shield is made

Although GE has not revealed composition of the material, it does say that the plastics substance can be made elastic, flexible or hard by



***Supersonic flame** of more than 5000 F is blasted at a specimen of GE's new nose cone material.*

For more information, circle No. 522

NICKELOID METALS IN A *Woman's World*

t of that happy gleam in the eyes of a modern homemaker is because of the con-
ience, the ease, and the pleasant decorative warmth of her kitchen. Along with the
t woods and pleasant colors she revels in the easy-to-maintain gleam of clean
ght appliances, housewares, working surfaces and decorative trim. The efficient
omium and the warm copper . . . seen so much about the modern kitchen . . . are
st probably stamped or fabricated from one of the versatile galaxy of Nickeloid
tals. There's eye appeal and there's sales appeal in appliances and housewares
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MERICAN NICKELOID COMPANY, PERU 6, ILLINOIS Plants: Peru, Ill., and Walnutport, Pa.

Kopp Glass

can create glass parts to meet your exact needs

BENEFICIAL PROPERTIES

Strong
Smooth
Hard
Won't rust, stain, warp
Resists scratching, moisture, heat
Tough
Accurate Colors
Stable
Transparent or Opaque
Controls light

Precisely Formulated to provide the *right* combination of properties

Suppose your product requires a component with some of the properties listed above. Glass may be your answer!

Kopp engineers have the experience, facilities and "know-how" to analyze your requirements *precisely*. They develop the "batch formula," properly proportioning and mixing carefully-measured ingredients.

This mix is melted under accurately-controlled temperatures and the molten glass is pressed to exact dimensions in Kopp-engineered molds. Subsequent cooling, annealing, grinding and finishing—under strict quality control—provide the components to meet your design requirements *exactly*.

Ask for Bulletin 553-A on "Kopp Engineered Glass"

KOPP GLASS

Kopp Glass, INC.

Swissvale, Pennsylvania

For more information, turn to Reader Service card, circle No. 378

new simplified molding techniques. In making the heat shield, basic materials are blended and heated in temperature controlled ovens, mixed to the proper consistency, subjected to an air removal process, and poured into molds.

The shielding material has been successfully tested in high temperature facilities, according to GE. In one such test, a supersonic flame of more than 5000 F was blasted at the material. In another, the material was subjected to temperatures of more than twice that of the surface of the sun.

What about other materials?

Most of the commercial reinforced plastics publicized as particularly suited for rocket and missile use seem to be intended for the temperature range of 3000 to 10,000 F. Of the commercial materials whose compositions are disclosed, most are phenolic with either asbestos or silica glass reinforcement. Materials suppliers are handicapped by security limitations, and no objective test results of proprietary materials are releasable. (For more information on high-temperature-resistant plastics for rocket and missile parts, see M/DE, June '58, p 100.)

Ceramic Adhesives May Replace Brazing

The Air Force, in cooperation with Aeronca Mfg. Co. and the University of Illinois, has expended considerable effort in developing a practical ceramic adhesive for use at temperatures over 500 F. The reasons: 1) ceramic adhesives are inexpensive; 2) they are resistant to nuclear radiation; 3) they are capable of withstanding temperatures up to 5000 F; and 4) they are easy to apply.

Brazing, which is now used for high temperature bonding, is expensive and requires complex manufacturing processes.

Research to date

The results of research performed by H. G. Lefort, R. M. Spriggs and D. G. Bennett of the University of Illinois, and reported in *WADC Technical Report No. 55-491, Part 3*, show that ceramic oxide, glassy-bond

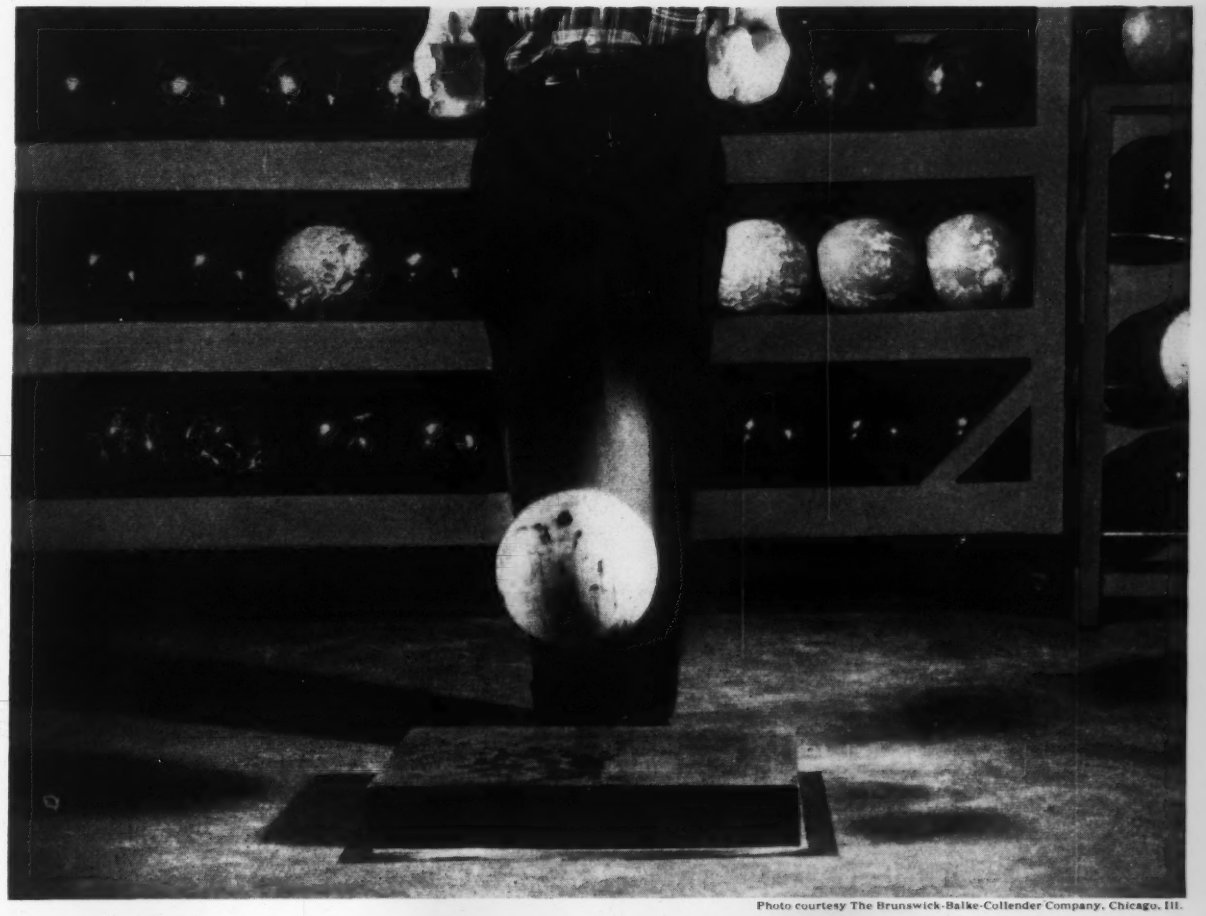

Photo courtesy The Brunswick-Balke-Collender Company, Chicago, Ill.

How to prepare for a lifetime of "hard knocks"

This bowling ball – being test-bounced against a concrete-embedded steel plate–is headed for a lifetime of "hard knocks." It will be hurled down hundreds of maple lanes – crash into thousands of tenpins. Yet, it must retain its perfect shape, balance and weight.

To measure up to those exacting requirements, the nation's foremost manufacturer of bowling balls used to rely entirely on natural rubber. Now, a synthetic rubber is used that actually improves the quality of the compound. And that's PLIOFLEX by Goodyear. Mixed with natural rubber and other basic ingredients, PLIOFLEX has enabled the firm to give a *lifetime guarantee* with every ball it makes.

It has also made possible greater processing efficiency with resultant savings in time and money. The exceptional uniformity of PLIOFLEX is a key reason for this – along with its excellent dispersion characteristics and good color stability. These qualities help make the finished product a unique combination of precision craftsmanship and incredible toughness.

If you're looking for a material that can bowl over production problems–and improve product–PLIOFLEX may be right down your alley too. For full information, plus latest *Tech Book Bulletins* on other synthetic rubbers and rubber chemicals, write Goodyear, Chemical Division, Dept. K-9437, Akron 16, Ohio.

GOODYEAR

CHEMICAL DIVISION

Pliofiex – T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

For more information, turn to Reader Service card, circle No. 380

IS IN REYNOFOAM* PRODUCTION

On the Reynofoam production lines at Reynolds Chemical Products high speed production combines with close, personal attention to detail . . . strict, knowledgeable inspection of the finished product . . . rigid quality control. For the customer, this means *lower* cost . . . higher quality.

These are requisites that every Urethane Foam user must seek—and they can be combined only where proved ability goes hand-in-hand with consistent performance.

Reynofoam, an exclusive product of Reynolds Chemical Products Company can be molded to your precise specifications and delivered to you with time, quality and cost considerations that are sure to please you.

* Reg. Trade Mark

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DIVISION OF STUBNITZ GREENE CORP.

For more information, turn to Reader Service card, circle No. 530

adhesives have tensile strengths exceeding 1500 psi at temperatures up to 1000 F in lap shear joints using 17-7 PH stainless steel.

The results of research performed by Joseph Bayer at Aeronca show that ceramic adhesives can be used to bond stainless steel honeycomb structures.

The ceramic adhesive used in bonding the honeycomb structure contained a porcelain enamel frit, iron oxide and stainless steel powder. The method used for fabricating the structure was to spray the adhesive in thin coats on the core and the facing sheets, then fire them separately to avoid oxidation. After firing, the structure was assembled in a special tool and fired at 1750 F for 15 min under 5 psi so that integral bonds were formed between the core and the facing sheets.

Bayer says more flexible adhesives should be developed and bonding techniques should be improved before ceramic adhesives find use in industry.

Cu-Zr Welding Alloy Is Strong, Ductile

An alloy of copper and zirconium for resistance welding has been developed by P. R. Mallory & Co., Inc., Metallurgical Div., Indianapolis 6, Ind.

The new alloy, called Mallory 28 metal, is said to have high electrical and thermal conductivity combined with high strength and hardness. Ductility of the alloy is such that it should not crack or check when highly stressed at elevated temperatures. The alloy also has good resistance to annealing or softening at high temperatures.

The alloy is recommended for spot and seam welding of aluminum and

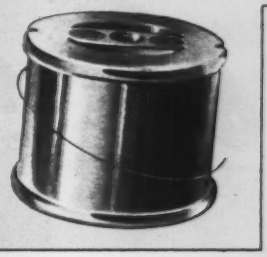
PROPERTIES OF MALLORY 28

Tensile Strength, psi	54,300
Yield Strength (0.2% offset), psi	48,900
Elongation (in 2 in.), %	27
Reduction in Area, %	82
Modulus of Elasticity, psi	16.8×10^6
Hardness (Rockwell)	B68
Elec Cond, % IACS	92
Ther Cond, Btu/hr/sq ft/°F/ft	203

SYLVANIA Precision-Plated WIRES

Type of Wire*	Standard Percentage of Plating	Typical Applications	Sizes, in Stock or in Process
NICKEL PLATED BRONZE	2, 4%	Extensively used in manufacturing wire cloth for Fourdrinier papermaking machines and other applications where corrosion resistance is essential	.008" to .050"
NICKEL PLATED BRASS	2, 4%	Woven wire cloth for less severe service than nickel plated bronze	.010" to .050"
NICKEL PLATED COPPER	10%	Incandescent lamp lead wires. High temperature cables for service up to 650°F.	.005" to .100"
NICKEL PLATED COPPERWELD	2, 4, 8%	Lead wires for electronic tubes and incandescent lamps. Combines strength, high conductivity and oxidation resistance.	.020" to .040"
NICKEL PLATED STEEL	2, 4, 8% (Base metal contains .06% carbon nominal)	Fluorescent lamp and electronic tube leads; grid side rods; high-temperature appliance lead-in wires for operating temperatures up to 500° F.	.005" to .050"
NICKEL PLATED INGOT IRON	2, 4, 8% (Base metal, .03% carbon max.)	Lead wires and grid side rods	.015" to .050"
NICKEL PLATED IRON	2, 4, 8% (Base metal, .06% carbon max.)	Lead wires and grid side rods	.010" to .050"
SILVER PLATED "D" NICKEL SILVER PLATED PERMANICKEL GOLD PLATED "D" NICKEL GOLD PLATED PERMANICKEL	5% 5% 4, 5, 6% 4, 5, 6%	All of these used for lateral grid wires in electronic tubes	.0015" to .020" .0015" to .020" .0015" to .020" .0015" to .020"

*Partial list. 25 types in stock or in process at all times.



- Most uniform plating obtainable
- Most complete line available

PLATED WIRES are normally plated at a size only slightly larger than finished size. In the Sylvania process, a ¼" rod is plated to the desired percentage (1% to 15% plating material) and the plated rod is then drawn to the required wire diameter. This process insures maximum uniformity.

The Sylvania process results in maximum uniformity, improves the physical characteristics and increases the density of the plated metal, providing maximum protection to the core material. Sylvania Plated Wires are processed and inspected to assure compliance with customer specifications for uniformity and reliability.

Sylvania engineers are available to aid you in the establishment of your purchase specifications on both standard and special plated wires. Samples of standard products are available for your evaluation. As specialists in plated, clad and alloy wires . . . the most complete line in the industry . . . Sylvania can offer an objective recommendation on the type of wire best suited to your needs. Write for literature today.

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GENERAL TELEPHONE & ELECTRONICS

PARTS DIVISION

Custom Molded Plastics
Custom Metal Stampings
Custom Welded Parts
Custom Assemblies
Alloy, Clad, Plated Wire
Plated Metal Strip
Electronic Components
Fluorescent Components

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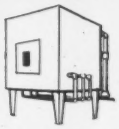
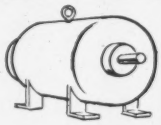
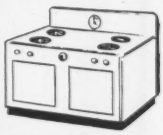
PART	COULD BE	REALLY IS
	Chemical resistant tool for scraping bottom of the barrel.	 Silicone gasketing for high temperature industrial oven.
	Tip for pogo stick used by a faint-hearted fakir.	A chemical and temperature resistant bellows used in jet aircraft.
	Last word in wrapping for a red-hot mummy.	 Special Silicone winding for an electric motor.
	Disguise for a half-masked refrigerator-raider.	Silicone gasket produced for the automotive industry.
	All-weather decoy for duck hunters.	 Heat-resistant Silicone extrusion used for oven gasket.

8301-SR

Guessing games can be fun . . . but not with rubber parts! Silicone rubber parts by Stalwart assure you high strength, maximum stability and superior dielectric qualities at temperatures ranging from −160° to +600° F. And Stalwart is the only producer of extruded and calendered *Silicone sponge parts.* Stalwart also accurately produces parts from a complete range of natural and synthetic rubber compounds to meet individual operating requirements. Write for complete information.

NEW! Send today for your copy of the Stalwart catalog.

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Manufacturing facilities in
Jasper, Georgia and Bedford, Ohio

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magnesium alloys, and welding of galvanized, aluminized, and tin and cadmium-plated steels.

The producer says the special properties of the material are developed through a combination of cold working and heat treatment. No details are available.

Other News . . .

Nonferrous metals

▸ Thin-walled butt-welded tantalum tubing is now available from Haynes Stellite Co., Div. of Union Carbide Corp., 420 Lexington Ave., New York 17. Standard sizes are 1, 1½ and 2 in. o.d., with 0.010, 0.013, 0.015 and 0.020-in. wall thicknesses

▸ Gold-gallium and gold-antimony wires, sheets and special shapes are now available from J. M. Ney Co., Maplewood Ave., Bloomfield, Conn. for use in semiconductor devices. Wire is supplied in diameters down to 0.0005 in., and sheet in thicknesses down to 0.001 in.

▸ Close tolerance phosphor bronze stampings for use as clips, springs, etc. are available from Federal Tool & Mfg. Co., 3600 Alabama Ave., Minneapolis 16, Min. The company says tolerances of ±0.002 in. can be held on some parts.

▸ Nonfading, gold colored, anodized aluminum sheet is now available from Kaiser Aluminum & Chemical Corp., 1924 Broadway, Oakland 12, Calif. According to the producer, the color is inherent in the sheet itself, rather than achieved through the use of dyes or other coloring agents.

Plastics

▸ A fast injection molding technique for small silicone rubber parts has been developed by Stoner Rubber Co., 7061 E. Monroe St., Anaheim, Calif. The producer says the new process offers substantial savings in the unit price of small silicone rubber parts. It is also said to offer lower original tooling costs.

▸ An improved, low cost plasticizer for high temperature vinyl wire insulations has been introduced by Enjay Co., 15 W. 51st St., New York 19. The plasticizer, *ditridecyl phthalate,* is said to pass Class O (194 F) and Class A (220 F) heat stability tests specified by Underwriters' Laboratories.

▸ A vinyl copolymer latex, said to

ECONOMY, DURABILITY AND DEPENDABILITY are outstanding characteristics of these sintered metal gears. Parts like these are the result of close cooperation between Moraine Products and its customers from idea through design and development to production.

Moraine Products

Vital parts for automotive progress • Division of General Motors, Dayton, Ohio

GM GENERAL MOTORS

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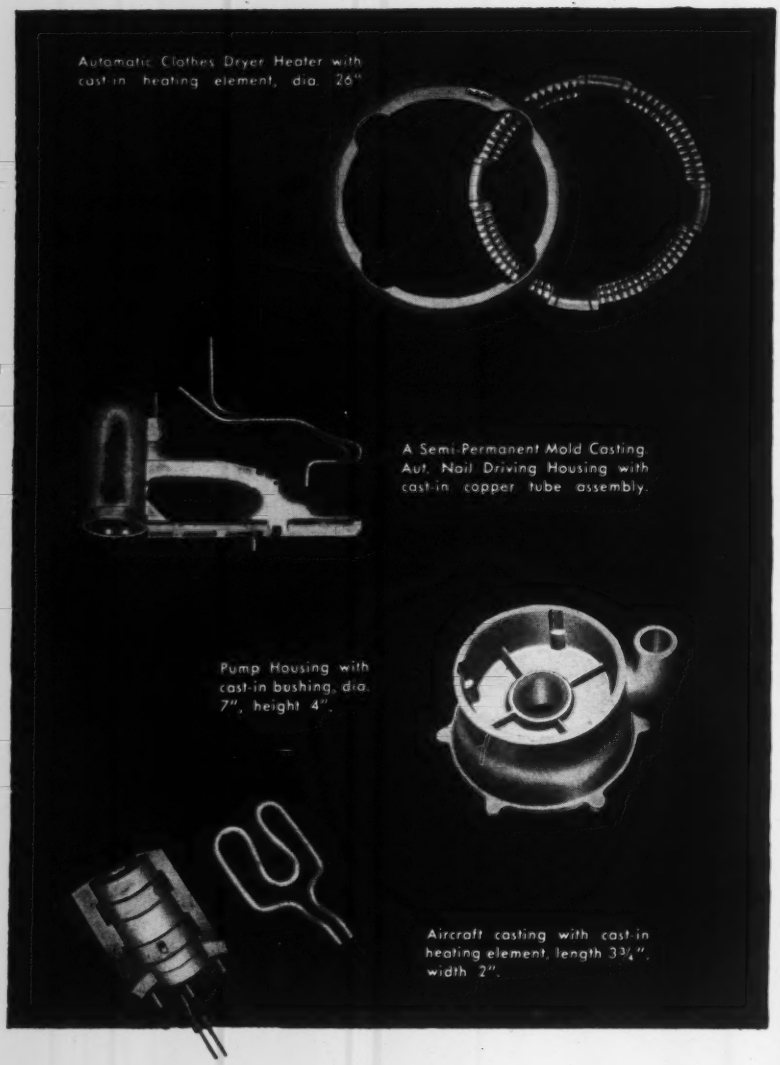
Automatic Clothes Dryer Heater with cast-in heating element, dia. 26"
A Semi-Permanent Mold Casting. Aut. Nail Driving Housing with cast-in copper tube assembly.
Pump Housing with cast-in bushing, dia. 7", height 4".
Aircraft casting with cast-in heating element, length 3¾", width 2".

COMBINATION PERFORMANCES "HARNESSED" WITH ALUMINUM PERMANENT MOLD casting

Your product design requirements may dictate a light weight, rust-proof casting, tailored to perform with a heating element, bushing or insert. ALUMINUM PERMANENT MOLD casting is the answer, as it is superior to other casting methods for holding and positioning metals selected for integral performances.

Shown here are examples of ALUMINUM PERMANENT MOLD CASTINGS already in use. All requiring the physical advantages of aluminum with bearing metals to resist frictional wear, and conductive metals for varied wattage loads. At EXALCO these are common requirements and create no production challenge to our skilled permanent mold casting engineers.

Your "finished product appearance" may be of primary importance. Our DURAGLAZE was developed by us to provide a finish that cannot crack or chip. It is mechanically applied to any flat or contour surface and assures greater durability than chemical and electro-chemical finishes.

Feel free to write us for production procedure and estimates of aluminum castings with or without cast-in features.

Exalco MANUFACTURING CO.
ALUMINUM IN PERMANENT MOLD AND SAND
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What's new IN MATERIALS

have exceptional heat and light stability, has been developed by Dow Chemical Co., Coatings Technical Service, Midland, Mich. The material is designed for use in textile coating applications. It is called experimental latex X-2726.

▸ Bacon Industries, Inc., 192 Pleasant St., Watertown 72, Mass. is marketing a modified epoxy potting compound packaged with a solid anhydride curing agent. The compound, called P-20, does not shrink on curing, is rigid, and has good thermal shock resistance.

▸ Reeves Bros., Inc., 1071 Avenue of the Americas, New York 18 has begun commercial production of low-denier polypropylene fiber. The fiber is available both as staple and in the form of continuous multi-filament yarns.

Finishes

▸ Uni-Clad is the name given to a new coating for use on glass-reinforced polyester and phenolic plastics. The coating is said to have good resistance to flexing, impact, abrasion, moisture, acids and alkalis. It was developed by Universal Paint & Varnish, Inc., Bedford, Ohio.

▸ A vinyl coating for fabricated steel, wood, paperboard and fiber products has been introduced by Kaybar Inc., Birmingham, Mich. The coating is said to bond securely to the base material for the life of the product.

▸ Amchem Products, Inc., Ambler, Pa. has introduced an amorphous chromate coating for aluminum. The product is particularly recommended for use in high production baths such as strip lines. The coating is called Alodine 1200S.

▸ Fidelity Chemical Products Corp., 470 Frelinghuysen Ave., Newark, N. J. has introduced a hot dip plastics coating for small metal parts. The coating, designated Dip-Pak No. 815, is shipped as a solid plastics block which is melted just before application. Parts are coated by dipping them in the molten plastic.

Testing equipment

▸ A tubular furnace is designed for tensile and creep testing of metals in a high vacuum at temperatures up to 4000 F. The furnace, called No. 59-TA, is 44 in. high and 11 in. in dia. It is available from Marshall Products Co., 270 W. Lane Ave., Columbus 2, Ohio.

For more information, circle No. 523 ➤

WITCIZER® PLASTICIZERS

STAYRITE® STABILIZERS

METALLIC STEARATES

For mold release, internal lubrication, heat and light stabilization

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Grades for every tinting need

WITCARB®

(Precipitated Calcium Carbonate)

Low-cost inert filler and extender for polyester resins

Helping you PINPOINT your plastics requirements

Need chemicals with that "tailor-made" quality for your plastics manufacturing processes? Then join the ever-growing number of manufacturers who are turning to Witco. For Witco offers a broad selection of chemicals to fill your most exacting requirements. The plastics industry has found that Witco products have dependable uniformity maintained by the strictest quality control in Witco's own plants.

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for urethane foams

WITCO 77-86

Coupler for urethane foams

SHAPE OF THE MONTH

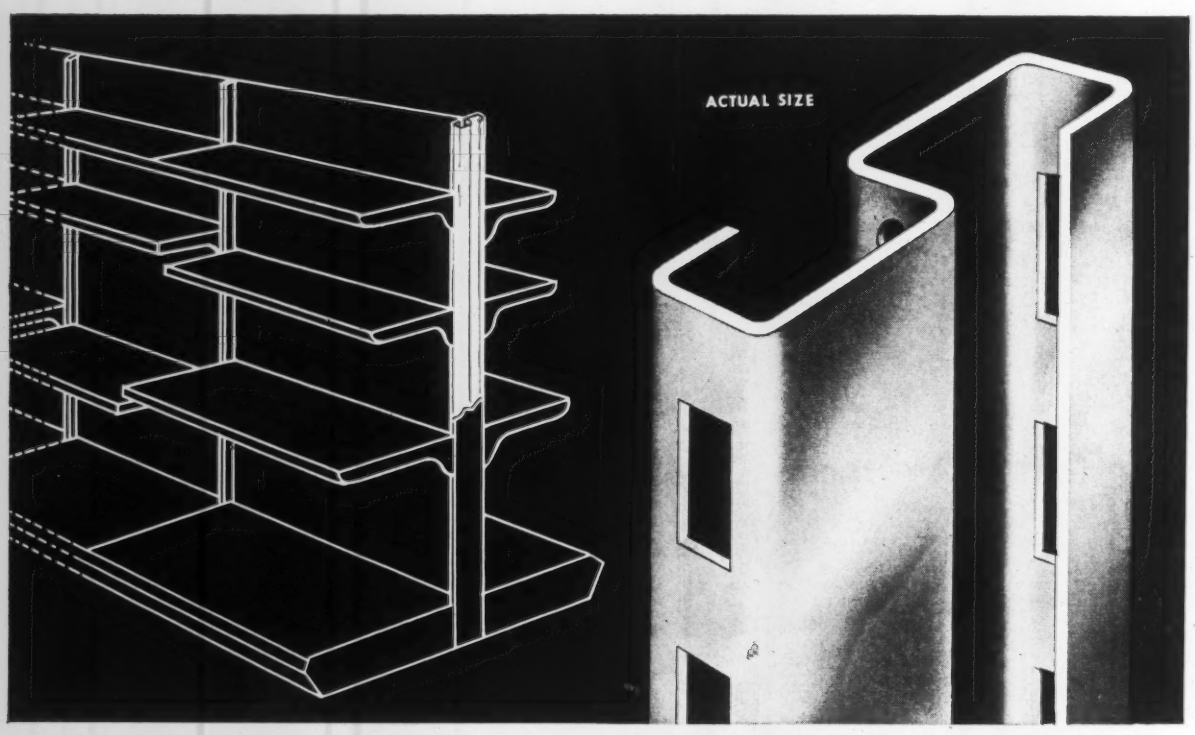
BY

VAN HUFFEL

Where ideas *take shape*

This upright shelving post is another of the many ideas Van Huffel roller die, cold forms in metal for a wide variety of applications.

Whether you require a simple or complex shape — in practically any coiled strip metal ½" to 33" wide — want it punched, notched, seamed, fluted, beveled, welded, coiled, curved or embossed — it's probable Van Huffel's experience, facilities and products can help you cut costs and make a better product. The handbook shown below tells you how.



MAIL THE COUPON FOR FREE METAL SHAPES HANDBOOK

Contains 48 pages of information on material selection, fabrication methods, tolerances and dozens of illustrated ideas that have taken shape in metal.

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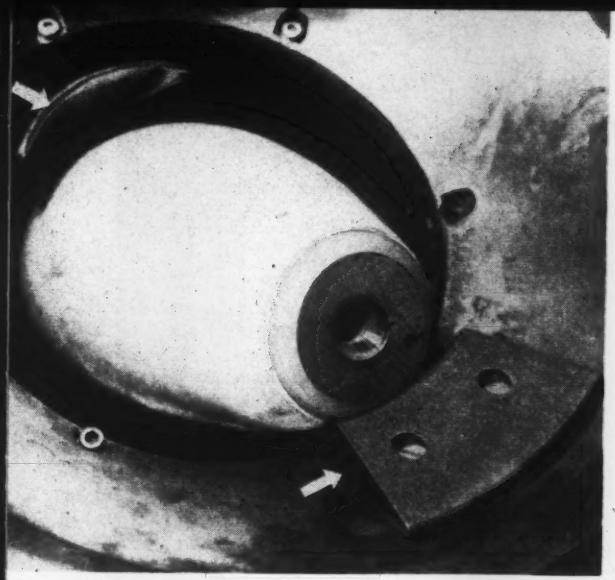
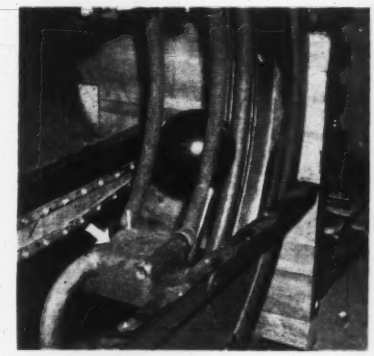


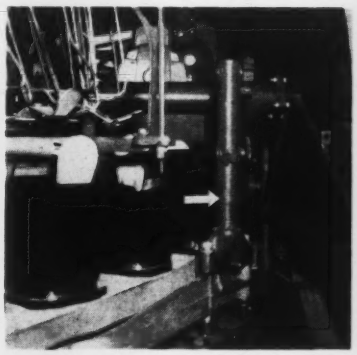
AT WORK

Pinsetter—cont'd from p 12

Pin guide block *used to guide individual pins into position when they are ready to be released. (The three malleable castings shown on this page and the one shown on p 12 are used in a redesigned bowling pinsetter.) Malleable was selected for the parts shown above primarily because it will not scratch or mark the pins. Other advantages: screw holes are integrally cast rather than machined, and finishing requirements are minimized.*



Ball rod connector *used to retain rubber-covered steel tubes which press ball against mechanism that rolls it to the return track. The casting is designed to pivot slightly to take up some of the shock as the ball is wedged in. Malleable was selected because its excellent fatigue resistance insures against failure from repeated shock loading. The steel tubes are easily tack welded to the connector.*



Deck post *used to support and raise and lower the pin deck (which contains the pins). The part shown here is actually a weldment consisting of a cast steel base, a steel plate bracket, a steel tubing post and two pins. This part has been replaced by a single malleable casting. Advantages: a 30% cost saving, elimination of all cutting, positioning and welding; and ease of machining and drilling holes.*

Welded Polypropylene for Tanks, Liners

Excellent resistance to heat and stress-corrosion cracking are the major reasons given for the selection of welded polypropylene for tanks and tank liners used in the chemical and process industries.

According to American Agile Corp., the availability of polypropylene tanks and liners marks a major step forward in the direction of increased use of plastics for structural applications.

Some of the advantages of polypropylene for these applications are:

1. The material has a melting point over 300 F and it behaves as

No. 7 of a series

Eastman 910 Adhesive solves another production bottleneck

Cinaudagraph, Inc. of Chicago, Illinois, manufactures radio and television speakers.

By switching from soldering to bonding with fast-setting, high-strength Eastman 910 Adhesive, Cinaudagraph eliminated a bottleneck in the assembly of a 2¾ inch speaker for portable transistor radios.

The adhesive bonds the pole tip to the magnet and the pole tip-magnet assembly to the speaker yoke, with excellent magnetic continuity.

The adhesive has been used successfully on more than 100,000 speakers. *Material costs were reduced 25%—labor costs, 50%.*

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is simple to use. No mixing, heat or pressure is required. Upon spreading into a thin film between two surfaces, setting begins immediately. With most materials, strong bonds are made in minutes.

What production or design problem can this unique adhesive solve for you?

For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9111 Dunbar Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. E-11, Kingsport, Tenn. (Not for drug use)

For more information, circle No. 454

GUARANTEED LAMINATED PLASTIC PARTS

Sheets, Tubes, Rods, Dies, and Tools
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For many years The Richardson Company has served industry as a skilled fabricator of high quality, uniform laminated plastic parts . . . produced to exacting customer specifications.

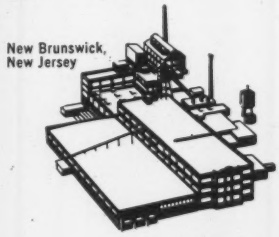
As the manufacturer of INSUROK® laminated sheets, tubes and rods, Richardson guarantees the finest fabricating materials in a wide range of NEMA, Federal and Special Grades.

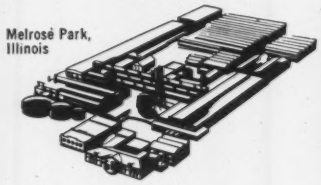
Fabrication dies and tools are designed and produced right in Richardson plants. Therefore, they are properly engineered for the material and will produce quality parts.

Two Richardson plants located in New Brunswick, New Jersey and Melrose Park, Illinois offer complete fabrication facilities for all forms of laminated plastics. This assures you prompt shipment of finished parts.

From ONE RELIABLE SOURCE you obtain quality materials, tooling, and fabricated parts.

To get more details on how Richardson's integrated fabrication facilities can serve you, write to The Richardson Company.





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LAMINATED AND MOLDED PLASTICS
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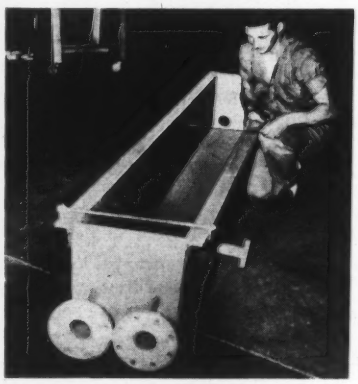
For more information, turn to Reader Service card, circle No. 486

a crystalline solid even at temperatures above 210 F. As a result, the tanks can be conveniently sterilized under standard autoclave conditions.

2. The tanks do not change shape even when exposed to temperatures up to 300 F, and a continuous operating temperature of 240 F can be easily tolerated (accelerated aging tests show negligible changes in physical properties after a 3000-hr exposure at this temperature).

3. The tanks and liners are resistant to a wide variety of corrosive acids, alkalis, salts, solvents and de-

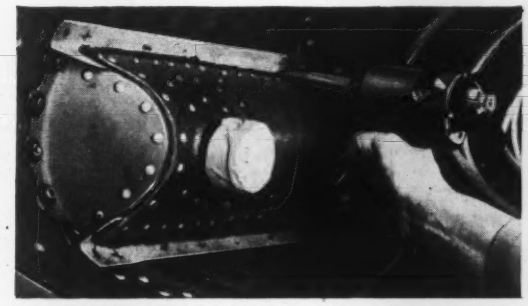
Welded polypropylene tanks. *Tests show that welds maintain strength even after 1000-hr immersion in boiling water; exposure to various corrosive acids, detergents, etc.; 3000-hr exposure to atmospheric steam; and exposure to a 10,000-v d.c. source.*



Polypropylene liner *for a steel tank used to handle sulfuric acid.*

General Electric RTV silicone rubber

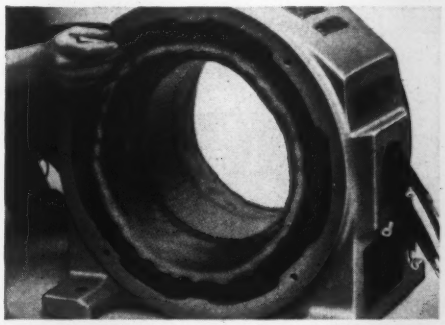
New liquid rubber cures without heat, useful from — 70 F to + 600 F, ideal for sealing, electrical insulation and flexible molds.



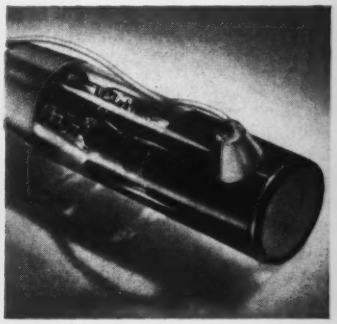
HEAT RESISTANT SEALING, such as shown on this Douglas DC-8 Jetliner, is made possible with RTV (room temperature vulcanizing) silicone rubber. RTV cures without application of heat; won't shrink (no solvents); forms no voids. It has excellent bond strength, plus resistance to high temperatures, moisture, weathering, ozone, aircraft fuels and solvents.

PRECISION MOLDING of prototype and engineering models and replacement parts is simplified and improved with RTV flexible mold material. G-E RTV's low shrinkage permits close tolerances and fine surface detail.

LOW-COST TOOLING with flexible RTV mold material offers added savings in time and expense. RTV's "built-in" release agent provides easy removal of this epoxy coil-winding form from mold. Total cost reduced 81%, delivery time 90%.



ENCAPSULATION OF STATOR WINDINGS, introduced by General Electric motor departments, extends service life of motors. RTV's resistance to moisture and other contaminants enables these dripproof motors to meet certain applications formerly requiring enclosed units.



POTTING OF AIRBORNE EQUIPMENT provides protection from high altitude arc-over and corona as well as vibration and moisture. RTV silicone rubber protects this cathode ray tube up to 70,000 feet.

RTV COIL IMPREGNATION enables this Hughes Aircraft Co. transformer to provide top performance at 250°. Unlike other insulations tried, G-E RTV compounds proved successful both for coil impregnation and full encapsulation.

For application data and samples of General Electric RTV silicone rubber write Section B1114, General Electric Company, Silicone Products Department, Waterford, New York

GENERAL ELECTRIC

For more information, turn to Reader Service card, circle No. 445

No. 3 of a Series

GRIPPING STORIES
from the files of Angier Adhesives

The Case of the BAFFLED DESIGNER

It was a tough job and "Rush", but now he had it licked. All he needed was the adhesive that would join the rubber component to the metal base. "No problem here," he thought, as he specified the rubber-to-metal formula that had been so successful in a previous job.

But there *was* a problem and it became more and more apparent as one after another of the trial bondings failed.

Once on the case, an Angier man unravelled the mystery in short order. He pointed out slight—*but important*—differences between the old product and the new—in rubber compound used, in end-product vibration and in heat and stress factors involved. He recommended an adhesive that was perfect in every respect and the designer met his deadline with two days to spare.

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MATERIALS AT WORK

Aluminum Co. of America

Aluminum tank *lined with polypropylene is capable of handling nitric and hydrochloric acids at 200 F for several days.*

tergent solutions.

4. The tanks are easily formed, worked, machined, shaped and welded.

Tantalum Heaters Prove Most Efficient

Tantalum bayonet heaters, which are said to have a heat transfer rate about seven or eight times greater than that of conventional heaters, are now being made by Pfaulder Co.

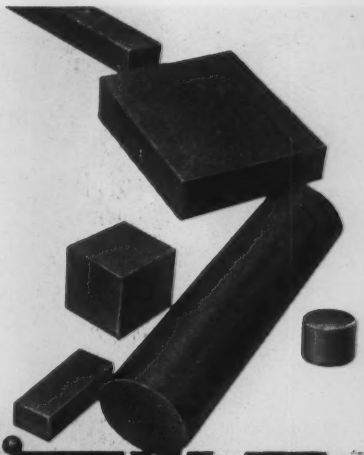
According to Pfaulder, tantalum was selected because its superior heat transfer rate and high ductility assure excellent resistance to physical and thermal shock. In addition, tantalum offers exceptional resist-

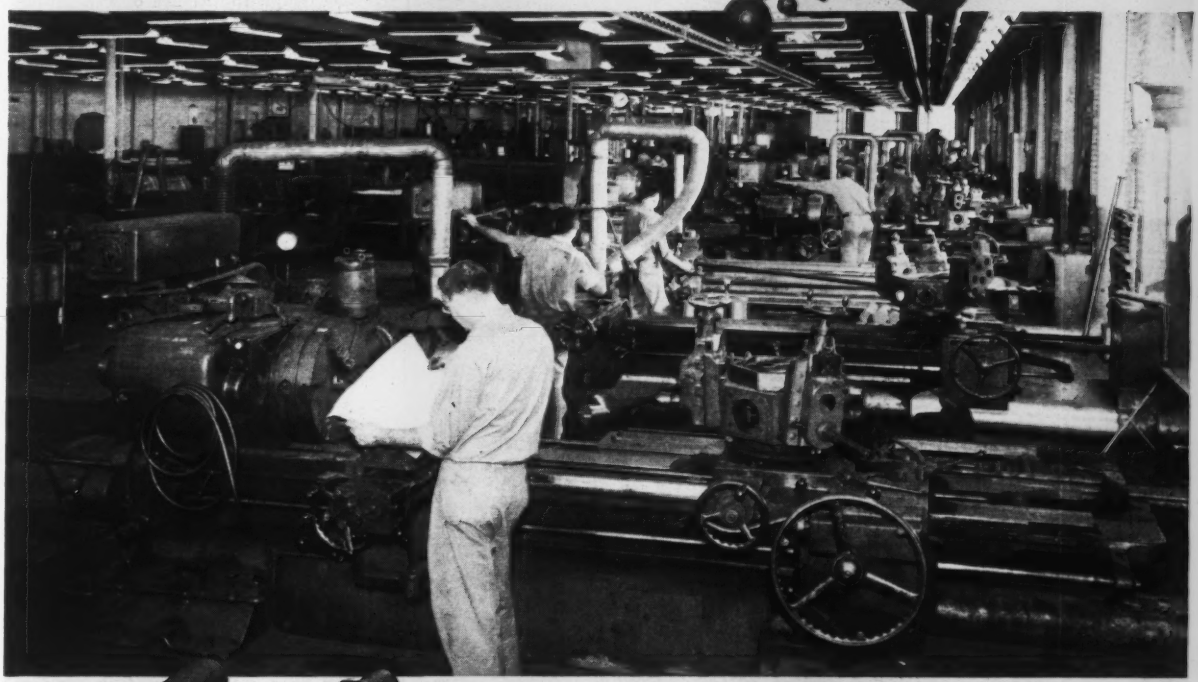
Bayonet heaters *made of tantalum.*

NATIONAL GRAPHITE
TRADE-MARK

is available in any size, shape and quantity!

Unmachined... *Graphite* is available from minute particles to five ton blocks... in all sizes of square, round, rectangular and cylindrical shapes. Whatever your needs—whether quantity, purity or size... made from standard or special grades—let National Carbon Company quote on your requirements.





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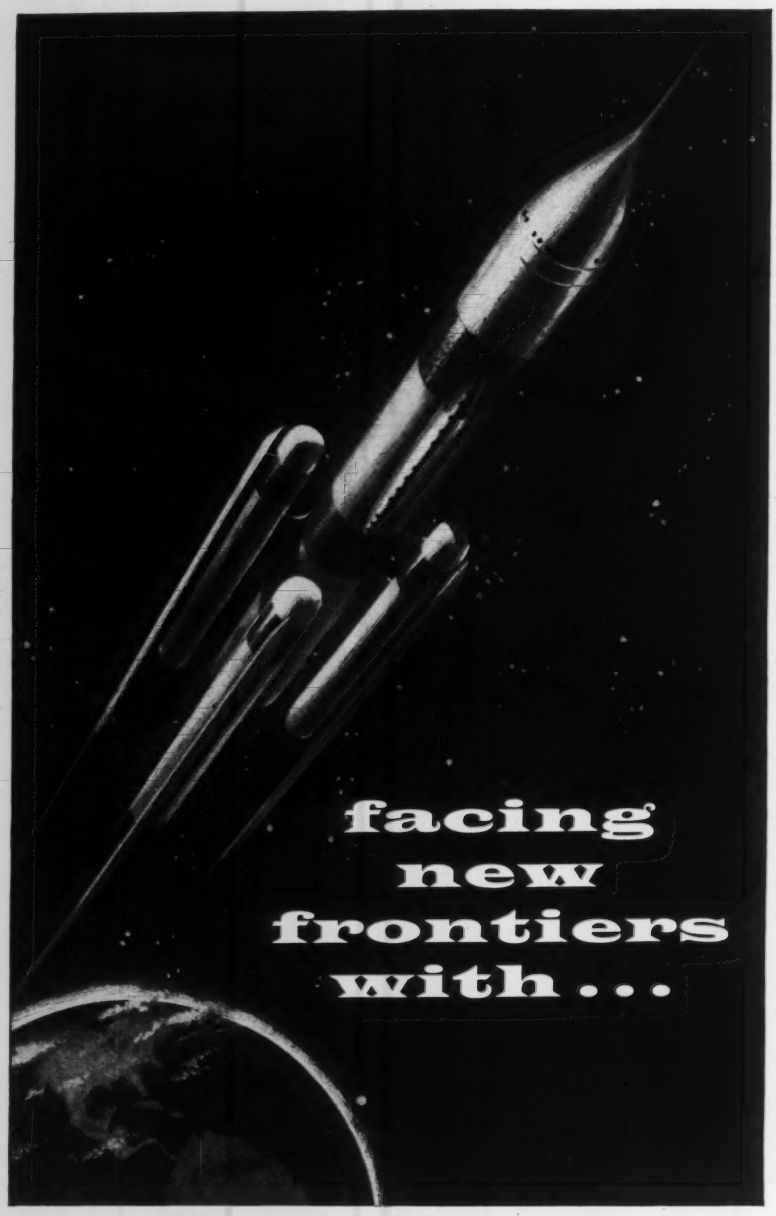
For more information, turn to Reader Service card, circle No. 541



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- high modulus
- high temperature strength
- excellent thermal conductivity

Today, beryllium parts are being designed by missile and aircraft manufacturers into *current* programs. This is one of the metal's growing new frontier areas.

A free illustrated brochure on Berylco HPA beryllium is available. Write to—

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P. O. Box 1462, Reading, Pennsylvania

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ance to corrosion (from practically all acids except hydrofluoric) and extremely thin wall sections can be used.

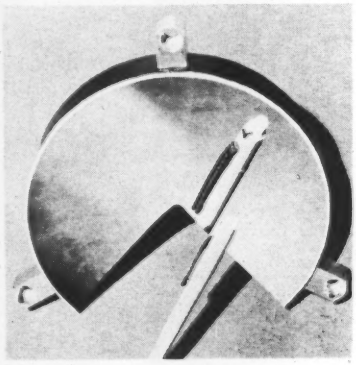
The new heaters have a 0.013 in. wall, as compared to 0.875 in. for standard high silicon iron or chromium-nickel alloy heaters currently being used in acid concentrators.

Although initial use of the tantalum heaters is expected to be primarily in acid concentrators, they should eventually prove useful in condensers, heat exchangers and unjacketed reactors. According to Pfaulder, life of the tantalum bayonet heaters under normal service should be about 20 years.

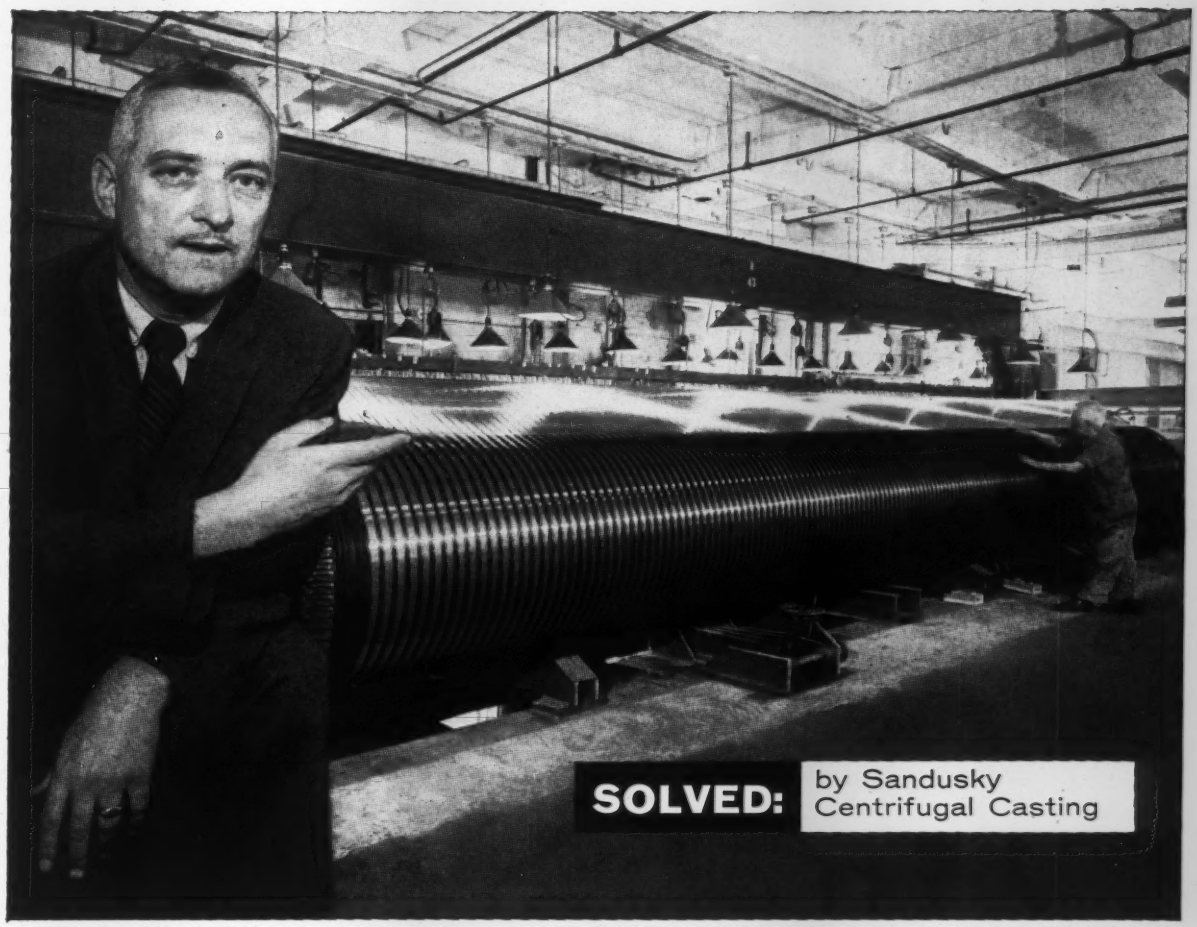
Cast Epoxy Mirror Better than Glass

Thanks to the use of filled epoxy and metallized aluminum, reflective optical components are now being produced at a fraction of the time and cost previously necessary. And the units are said to be better. According to Military Products Div., Singer Mfg. Co., paraboloids, hyperboloids, ellipsoids and other complex aspheric surfaces are now being easily mass produced.

Here's how the mirrors are made: a negative is cast from a precision ground glass master mirror and is used as a mold for casting positive replicas. Both the negative and finished product are made of filled epoxy. The reflective surface is



***Aluminized epoxy mirror** costs less, is more easily produced than glass mirrors.*



Eastwood-Nealley's chief engineer points out great size of grooved cylinder

Who else could cast this 22-ton cylinder for the world's biggest wire cloth loom?

To weave Fourdrinier wires up to 352" wide for the world's newest and largest paper machines, Eastwood-Nealley Corp., Belleville, New Jersey, required a cylinder over 30 feet long.

Sandusky supplied this 44,685 lb. roll, centrifugally cast of SAE-1030 steel and rough machined to 363" in length, 40⅛" on the O.D., to be used as the backbeam on Eastwood's new wire cloth loom. Since the cylinder had to be machined with 176 extremely smooth 2" x 2" stirs (grooves) in which wire is wound, it had to be of *flawless quality.* Otherwise any voids or inclusions exposed by machining would nick the delicate bronze strands and cause the expensive wire cloth to fail.

Eastwood-Nealley's chief engineer, Clemson A. Bower, asserts: *"We chose a Sandusky Centrifugal Casting because only Sandusky could make such a gigantic cylinder without welding. We were confident that our special machining operation would be accomplished without costly re-makes, for in the 12 years we have been using them, we never found a single flaw in a Sandusky Centrifugal Casting!"*

When cylinders or piping are needed in your design, keep Sandusky Centrifugal Castings in mind. We can supply cylindrical products from 7" to 54" O.D. and up to 33 feet long—made from a variety of alloys including stainless, carbon and low-alloy steels as well as copper- and nickel-base alloys. Send for free booklet, "Your Solution to Cylindrical Problems."

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FOUNDRY & MACHINE CO.

SANDUSKY, OHIO Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

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ANNOUNCING

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FIRST AUTOMATED IRON PHOSPHATE PROCESS! *and it's "cold," too!*

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AUTOMATED GRANODINE 663—the industry's first—takes the human element out of quality control . . . replaces it with 100 percent electronic line control, every hour of every day! You get positive, electronic vigilance on the line that adds up to savings in time, labor and chemicals—yet overall coating uniformity and quality never varies!

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Put your phosphate processing on a more productive basis with the first completely automated phosphating line in the metalworking industry. Write, wire or phone your local AMCHEM representative for further information on cost-saving, time-saving Granodine 663!

Write for Bulletin 1698 on Granodine 663—contains eye-opening quality control data that will interest your company's financial experts!

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Check these Automated GRANODINE 663 Features...

- ✓ Automated—for round-the-clock quality and bath stability!
- ✓ Cold—for substantial heat savings!
- ✓ Lowest coating weight consistent with top quality!
- ✓ Powder-free coatings, continuous and adherent!
- ✓ Sludge-free bath!
- ✓ No oxidizing accelerators required!
- ✓ Readily soluble powder form, cheaper to ship, easier to store!

...and call your Amchem representative today!

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MATERIALS AT WORK

vacuum metallized aluminum overcoated with a silicon monoxide protective film. The aluminized layer is usually 0.000005-0.000008 in. thick.

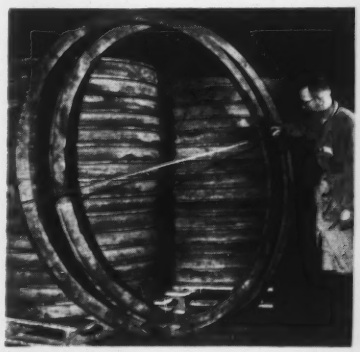
According to Singer, the epoxy-aluminum mirrors not only faithfully duplicate the most intricate configurations, but provide superior physical properties as well. For example, the replica mirrors offer greater resistance to thermal shock because the rate of thermal diffusion through epoxy is much greater than it is through glass. In addition, the mirrors can be quickly mass produced with unsymmetrical surfaces which previously took up to two weeks to produce in glass. The part shown in the accompanying photo would have been almost impossible to produce in glass.

Other important advantages of the epoxy-aluminum mirror are: 1) cost is about one-fourth and time about one-tenth that previously required; 2) mounting brackets, fixtures and mechanical components can be cast directly into the epoxy backing; 3) weight is greatly reduced; 4) corrosion resistance is equal or superior to that of conventional glass.

Largest Titanium Ring Used in Space Capsule

Shown in the accompanying photo are what are believed to be the largest diameter rings ever made of titanium.

The rings, produced by the flash butt welding process and measuring 74 in. in dia and 2⅞ in thick, will

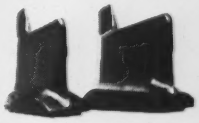


***Welded titanium rings** are 74 in. in dia.*

Choose the material that gets **stronger** when the heat's on!

√ solid-fuel rocket nozzle inserts

√ divergent cone sections



√ rocket vanes

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Speer Graphite is the "machinable ceramic" that resists thermal shock, is chemically inert, doesn't warp, actually gets stronger as temperatures increase up to 5432°F. That's why it plays so many vital roles in rockets and missiles!

Close tolerances are easy to machine and *maintain* in parts made of Speer Graphite. Excellent thermal and electrical conductivity, capability of impregnation with fluids, or of coating with metals and non-metals, and self-lubricating qualities add to the usefulness of Speer Graphite. If your parts require these, and other important high-temperature characteristics, Speer Graphite is the answer. Mail the coupon for the whole story.

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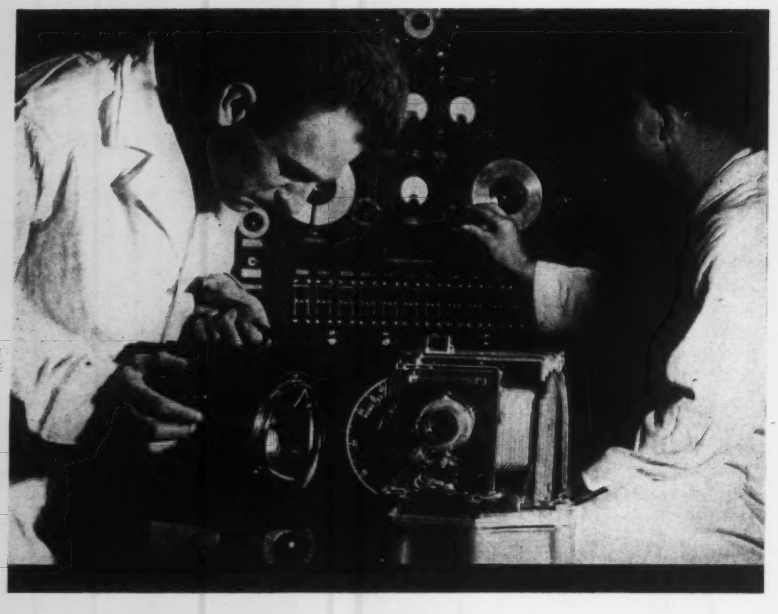

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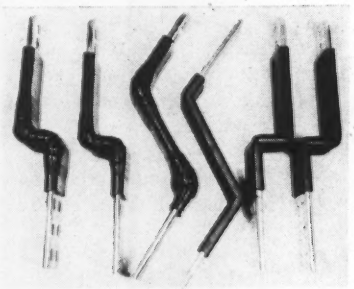
be used in the man-carrying space capsule scheduled to be launched as part of NASA's Project Mercury (see M/DE, Sept '59, p 11).

According to American Welding & Mfg. Co., titanium was selected because it satisfied strength requirements at exceptionally low weight. The rings weigh 70.6 lb; if made of stainless steel, they would weigh 353 lb.

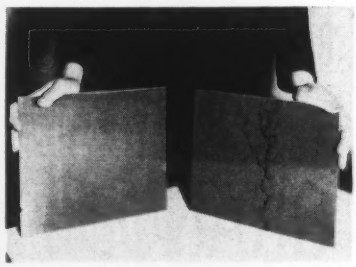
Reinforced Plastic Insulates Bus Bar

Cast or molded glass-reinforced polyester resin is now being used as an insulating material in the design of bus bars, bus supports and phase barriers in metal-clad 5 and 15-kv switchgear.

According to Federal Pacific Electric Co., reinforced polyester was selected in preference to phenolic or



***Integral casting** of glass-polyester insulation (right) assures constant thickness, eliminates hand wrapping of bends and offsets (left).*



***Glass-polyester panel** (left) shows no deterioration after a 250-hr exposure to 15-kv, surface scintillating arcs in 100% saturated salt-fog; phenolic laminate (right) shows heavy dendritic carbon tracks after only 10 hr.*

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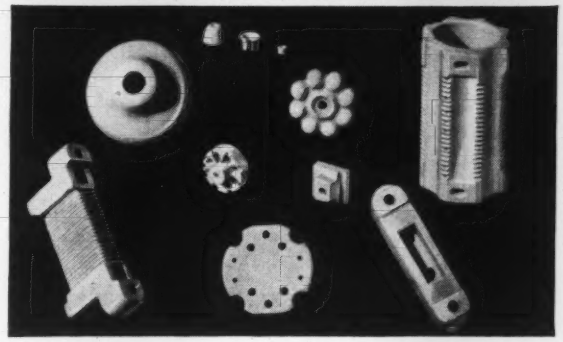
why STAR ?



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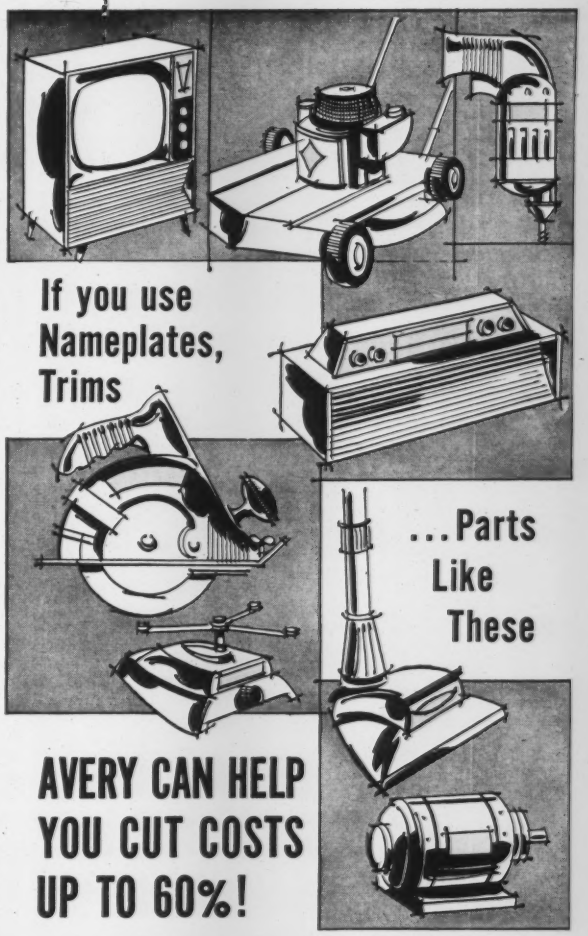

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What's more, Avery nameplates and trims are exceptionally attractive . . . add an air of "quality" to every product. Available in a variety of new metallics — mylar, foil, and vinyls.

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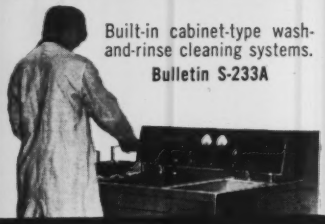
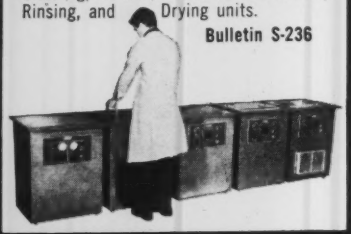
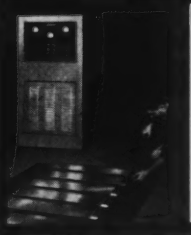
½-gallon and larger benchtop models, and (illustrated) 5- and 12-gallon self-contained rollaround units.
Bulletin S-509, S-217B



Built-in cabinet-type wash-and-rinse cleaning systems.
Bulletin S-233A



Modular cabinet-type systems with Cleaning, Filter / Heater / Recirculator, Rinsing, and Drying units.
Bulletin S-236



Custom-engineered cleaning installations: for batch and conveyorized cleaning, and for continuous-flow cleaning in strip and wire mills.
Bulletin S-235

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For more information, circle No. 409

MATERIALS AT WORK

epoxy because it offers the best combination of properties: excellent resistance to tracking and flame; high dielectric and impact strength; and extremely low power factor, moisture absorbency and corona loss.

According to Federal Pacific, the switch to glass-reinforced polyester not only improved the product, but made it possible to use metal-clad switchgear in areas where it was previously impossible. In moist, humid areas, for example, previously used bus insulation was subject to tracking. As a result, more costly and complicated equipment had to be used.

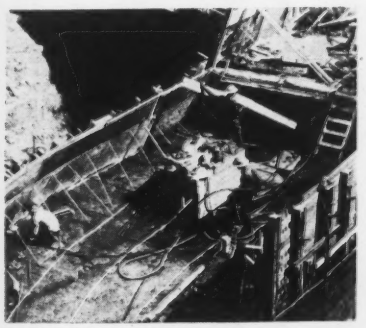
Aluminum Tubing Cools Concrete Dam

The switch from steel to aluminum has resulted in a saving of almost $10,000 in the cost of tubing used to prevent cracking during construction of concrete dams.

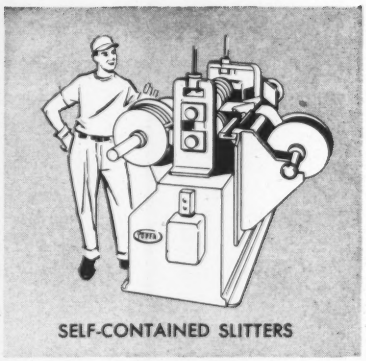
According to Aluminum Co. of America, 33,000 ft of 1-in. dia tubing were embedded in the concrete structure. Water circulating through the aluminum tubes removes the heat generated by the hardening concrete and helps to prevent cracking.

To build the dam, concrete sections were poured, one atop the other, in a series of steps. Each section is 5 ft high and as much as 50 ft long. The aluminum tubing was installed on the top surface of each section.

Advantages offered by the aluminum include: excellent uncoiling and bending characteristics, thus eliminating the need for mechanical



Aluminum cooling tubes *remove heat generated by hardening concrete.*



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YODER accessories, such as coil cars, swivel unloaders, scrap choppers, scrap disposers, plate levelers and coil boxes, make stock handling fast and easy.

YODER also makes a complete line of Cold Roll-Forming equipment and Pipe and Tube Mills. To profit from YODER'S years of engineering and service experience, contact your local YODER representative or send for the fully illustrated descriptive, YODER Slitter Manual; it's yours for the asking. Write to

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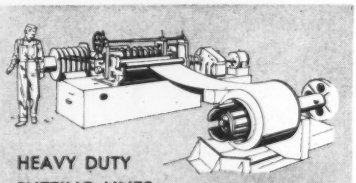
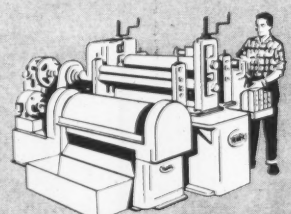


HEAVY DUTY SLITTING LINES



SCRAP CHOPPERS

ENGINEERING YODER MANUFACTURING

ROTARY SLITTING LINES

For more information, circle No. 363

Tool Steel Topics

BETH EHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

BEARCAT EMBOSSES INTRICATE GOLD

10k gold strikings for class rings no problem for this outstanding shock-resisting tool steel

Bearcat tool steel is performing brilliantly at The Metal Arts Co., Inc., Rochester, N. Y., where it is used in embossing 10k gold ring shanks and bezels for high school and college class rings. Bearcat was suggested by our local tool steel distributor, The Burke Steel Co., Inc., Rochester.

"Of course there are other grades which might be satisfactory," the Burke representative told them, "but what you are looking for is outstanding shock-resistance. Put Bearcat to work in this job and you'll never be sorry."

At last report, the dies were bearing out the prophecy. Hardened to Rockwell C-58-59, and operating in drop hammers, they had turned out thousands of the intricate gold strikings, without any sinking or breaking.

Bearcat, our super grade of shock-resistant air-hardening tool steel, takes shock jobs in stride, and has superior wear-resistance. And because it's air-hardened, Bearcat minimizes quenching hazards and distortion in heat-treatment.

Next time you're looking for a really tough tool steel, team up with Bearcat. You'll be glad you did.

For more information, turn to Reader Service card, circle No. 440

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Stainless Is Tough On Tools

Many items formerly made of soft steel are now being made of stainless steel. The austenitic stainless steels (AISI 300 series) are popular because of their corrosion-resistance, plus their strength and oxidation-resistance at moderately high temperatures.

Whenever stainless parts are made with tools formerly used on soft steel, there is a marked decrease of production of parts per tool. For example, on a simple blanking operation on stainless steel, the production per grind on the punch and die usually is about one quarter of the production on soft steel.

Though it is rarely possible to change conditions so that the "normal" tool life can be realized when making stainless parts, some improvements can be made. For example, if the blanking tools were originally made of AISI W1 water-hardening or O1 oil-hardening tool steels, a change to D2 high-carbon, high-chromium tool steel is suggested. This change will improve the tool life from two to three times. Or if D2 high-carbon, high-chromium tool steel is already being used, it may be necessary to carburize, or to nitride, in order to improve the wear-resistance. Close attention must be paid to mechanical conditions, such as proper clearance between punch and die, proper penetration of the punch, and optimum grinding procedures in finishing the tools.

Because stainless is tough on tools, careful planning is necessary for good tool life.

Write for

BETHLEHEM TOOL STEEL LITERATURE

If you would like to have booklets on our tool steel grades, just check your choice below, and mail to Room 1043, Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

- ☐ Hot Work
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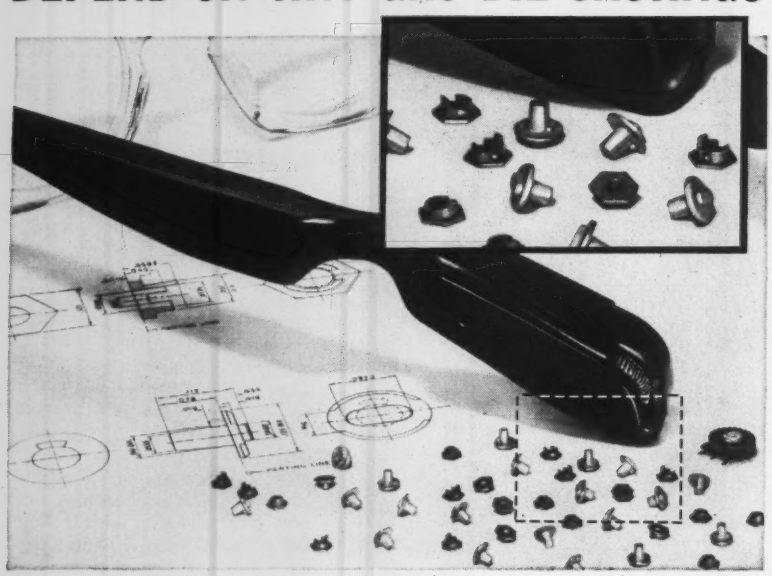
- ☐ Bearcat
- ☐ Tool Steel Selector

MINIATURE HEARING AID CONTROLS DEPEND ON TINY GRC DIE CASTINGS



Tiny, uniform zinc alloy parts to watchmaker's specs achieved through GRC's exclusive methods

A modern hearing aid small enough to fit into the temple piece of an eyeglass frame requires components and parts that must meet the same exacting specifications as the parts for a fine watch. Design engineers at Centralab, a division of Globe-Union, Inc., turned to Gries to produce the two tiny precision parts forming the mechanical center of a newly designed "Micro-Miniature" hearing aid volume control potentiometer . . . a .112" shaft and a bushing measuring .125" in diameter.

To function properly the two mating parts had to be manufactured within tolerances of ±0.0005". The shafts—9500 to a pound—were cast with a button-like disk and fastening lug at one end; a projecting tapered shaft for the bushing to rotate on and a stop lug to limit rotation on the other end. The even smaller—21,000 to a pound—slotted bushings were formed with a hex nut section and an extension to engage the shaft's stop lug. Electrical contact is made through the bushing.

This is a typical example of how GRIES' exclusive patented single cavity methods for automatically producing tiny, uniformly accurate, precision parts, economically solved a design problem. Whether simple or complex, quality is always high—no secondary operations, no scrap loss. GRC parts leave the machine ready for immediate use.

GRIES' exclusive single cavity methods open new approaches to product design . . . economical production shortcuts. Find out how GRIES can help you. Write for GRC bulletins on small zinc alloy die castings and molded thermoplastic parts or send prints for immediate quotations. Maximum sizes 1¾" long, ½ oz. in zinc alloy; 1¼" long, .03 oz. in plastics. No minimum size.

Write, wire, phone today for GRC's new detailed fastener catalog—your handy guide to low cost quality fasteners.

GRC Die Cast Zinc Alloy Washer Base Wing and Cap Nuts Eliminate Separate Washers

Save inventory, assembly time, and labor, with these wide-diameter washer base nuts. GRC offers prompt delivery from stock in a complete range of 14 thread sizes: #6 through ⅝". Used for all normal requirements and wherever separate washers would be required. Especially suited for oversize bolt holes, adjusting slots, soft surfaces.

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MATERIALS AT WORK

tube benders; elimination of many points of possible leakage; excellent kink resistance; ability to withstand crushing loads; and resistance to the corrosive effects of concrete.

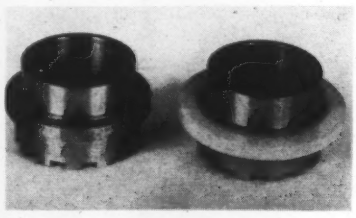
When the dam is completed, the aluminum tubes will be filled with grout and left in place.

Nylon Replaces Metal in Machine Tools

Extruded and machined nylon is becoming increasingly popular with designers of machine tools because it offers an excellent combination of advantages: reduced noise level, improved machine operation, reduced lubrication requirements, increased machine life and, in some cases, reduced total costs even though nylon may cost more than the metal part it replaces.

A good example of reduced costs and improved operation through the use of nylon is a universal milling machine which uses nylon for three major parts—the clutch gear collar and the cross and table feed lead screw nuts. The clutch gear collar, which is subject to considerable wear, replaces a 3-in. o.d. metal ball bearing which had a short life as a result of side loading and high frequency vibration. The nylon collar, machined from 3-in. o.d., 2-in. i.d. nylon, not only lasts longer, but costs about two-thirds less.

The use of nylon for lead screw nuts is more critical because the accuracy of any horizontal setting depends on removing backlash from the longitudinal and cross feed. According to Polymer Corp. of Pennsylvania, the switch from bronze to nylon reduced wear and backlash by two-thirds.



***Nylon clutch collar** (right) costs less, lasts longer than metal ball bearing (left).*

THE TONY ACCETTA "PET" SPOON, made of Revere Brass Strip has been awarded the Medal of Honor by Sportsman's Club of America for superiority of design and fish-getting ability while all Tony Accetta Baits have received National Sportsman's Research Award . . . a real tribute to design, construction and effectiveness.

Revere helps "fit the metal to the job"

AND A BAIT MAKER SAVES ON FORMING AND FINISHING COSTS WHILE PRODUCING AWARD-WINNING LURES

The fishing lures of Tony Accetta & Son, Riviera Beach, Florida, are known all over the world for their ability to catch fish. That's due to design. They are also known for their fine workmanship and ability to take a hammering on rocky reefs and shoals, and still retain their ability to attract fish. That's due to the material from which they are made . . . a Revere Brass with special grain size and finish.

Says the Senior Accetta, "The high quality of Revere Brass has, without a doubt, contributed immeasurably to the quality of our lures. In fact, Revere Brass is of such fine quality and finish, uniform grain size and structure that even after stamping and forming only a minimum of work is required prior to chromium plating. This means we save on both forming and finishing costs. Since we have been using Revere Brass we have not had a single customer complain due to poor quality material."

Why not put the extensive knowledge of Revere's sales representatives to work for you? With the wide variety of metals at their disposal, perhaps they can help you select the metal best suited for the job, with a resultant saving of money while improving product quality.

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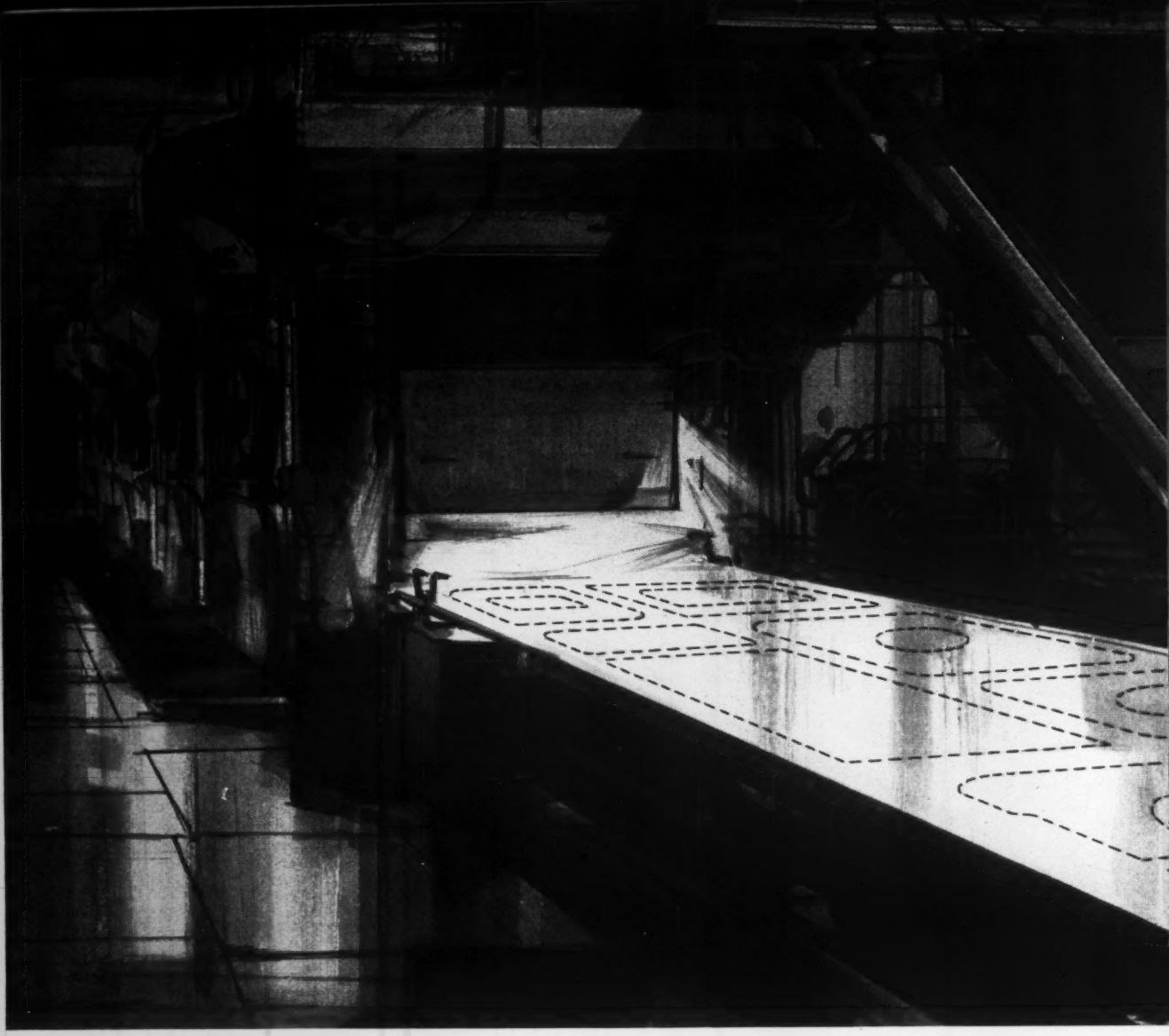

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WEIRTON STEEL COMPANY

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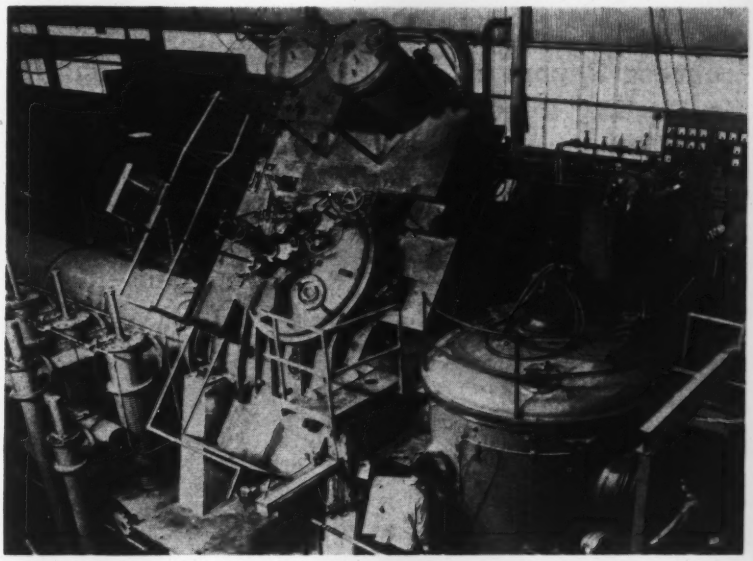
More Materials Research Seen as Key to Next Decade

". . . The next ten years will probably be known as the decade of materials research. We will see, compressed into that 10-year period, what would normally require 50 years' research efforts."

These remarks were made by Dr. Charles N. Kimball, president, in Midwest Research Institute's latest annual report.

This intensified research over the next ten years, Dr. Kimball says, will result in lighter metals, wider use of plastics, materials with resistance to higher temperatures, increased use of chemicals for applications heretofore considered impossible, new electronic systems, new coatings, and many other new materials.

Dr. Kimball pointed out that "space flight—to which this nation is completely committed—forces us to meet new environmental conditions such as very high vacuums, cosmic rays, ionized gases, acceleration, vibration, and shock."



Largest vacuum induction furnace in the world is claimed by Kelsey-Hayes Co.'s Metals Div. The 5000-lb unit will be used to produce superalloy ingots up to 5000 lb.

Foam Insulation Gets Set of Specs

A new set of specifications for expanded polystyrene for use as thermal insulation has been approved and is now available from the Expanded Polystyrene Manufacturers Task Force—a group of major producers of the material.

The new specifications cover both plain and self-extinguishing types of molded and extruded expanded polystyrene. The specifications were determined by an extensive testing program conducted at the research center of one of the manufacturers. Check testing was performed at the laboratories of several other members.

Manufacturers participating in the group are: Armstrong Cork Co., Dow Chemical Co., Dyfoam Corp., Johns-Manville Corp., Koppers Co., Inc., Mundet Cork Corp. and United Cork Cos.

Copies of the specifications are available from Arthur L. Faubel, acting secretary, Expanded Polystyrene Manufacturers Task Force, Rm. 736, 342 Madison Ave., New York 17.

X-Ray Standards for Steel Castings

A research program aimed at developing x-ray standards for determining the strength of steel castings has been started by Convair Div., General Dynamics Corp.

To develop the standards, Convair will 1) induce imperfections in a cast steel slab, 2) x-ray bars containing the imperfections, and 3) test the bars to destruction. By comparing the x-ray and strength characteristics with those of a perfect

slab of cast steel, Convair hopes to come up with a new set of x-ray standards.

According to Convair, a similar program for aluminum and magnesium castings has already been successfully completed.

Industrial Designers Will Meet This Month

"Planning by Design—In a World of Product Change" is the theme around which the American Society of Industrial Designers has planned a special conference Nov 12-13 at the Statler Hilton Hotel, New York City.

The conference, arranged to be of interest and value to engineers, designers and other executives, will cover planning, designing, pricing and selling a product. Some of the specific subjects to be covered are: 1) how major product planning problems are being handled; 2) materials, components and processes that will alter existing products; and 3) the contribution of industrial design.

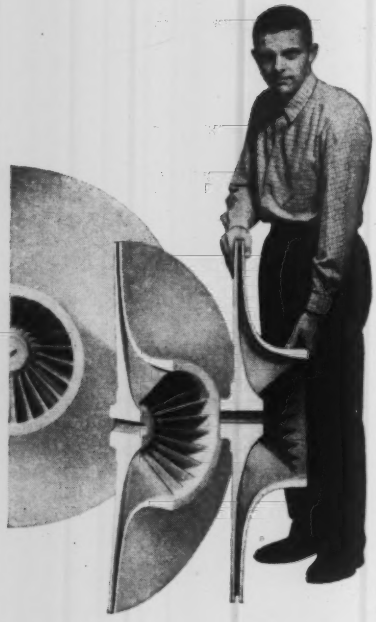
Progress Report on Die Casting Research

Development of improved die and core materials, studies of metal flow, and evaluation of new vacuum die casting methods are some of the many important research projects currently occupying the Die Casting Research Foundation of the American Die Casting Inst.

Progress reports on these and other projects were presented at the 1959 ADCI annual meeting held recently in Chicago. Some specific results of investigations conducted during the past year include:

1. The development of a basic equation that relates the variables

AWARDS COMPETITION—Entries for the 4th annual Awards Competition for the Best Use of Materials in Product Design are due Feb 1, 1960. See p 142 for details.



Large aluminum impellers cast smooth and accurate with metallurgical quality for high speed applications are among the specialties of Morris Bean and Company, Yellow Springs 1, Ohio.

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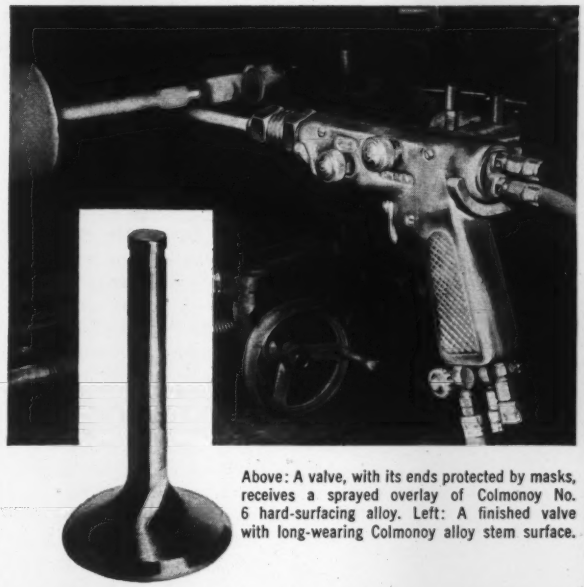

Above: A valve, with its ends protected by masks, receives a sprayed overlay of Colmonoy No. 6 hard-surfacing alloy. Left: A finished valve with long-wearing Colmonoy alloy stem surface.

Colmonoy Spraywelder Builds Longer Life into Aircraft Valve

To overcome corrosive pitting and abrasion of aircraft engine valve stems, more than one manufacturer has chosen Colmonoy No. 6 alloy to provide a long wearing stem surface. Colmonoy No. 6 stops the pitting and excessive wear which necessitates frequent engine overhauls. The Colmonoy Spraywelder is used to apply the powdered alloy. It works fast and makes smooth, controlled-depth overlays that finish up in minimum time.

Besides being an ideal method of applying a hard surface to finished machined parts, the Spraywelder employs the finest of hard-surfacing materials: Colmonoy nickel-base alloys. There are now five Colmonoy alloys available as Sprayweld* Powders.

Call a Colmonoy sales engineer to get an appraisal of your wear problems and information on just how Colmonoy alloys and methods might solve them. Colmonoy alloys (nickel-, cobalt-, and iron-base) are also applied in many other ways: as welding rod, electrodes, paste, and as castings. Learn more about this remarkable group of alloys.

Ask for the Spraywelder Catalog and Colmonoy Hard-Surfacing Manual No. 79.

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*Stabilization at 700°F provides absolute stress relief without loss of properties or machineability.

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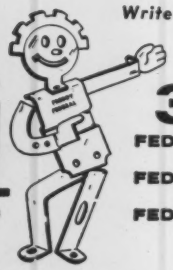

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of a die casting process to the heat checking of the die casting die steel.

2. The discovery that molybdenum offers remarkable resistance to heat checking and is therefore an excellent core material (see M/DE, Sept '59, p 202).

3. A systematic study of the principles of metal flow in die casting dies, including a comprehensive review of available literature.

4. The development of a compatible vacuum die casting method consisting of alternate vacuum systems which can be used on either zinc or cold chamber die casting machines.

Plastics Engineers to Discuss Stability

A special one-day conference on "Stability of Plastics" will be held Dec 1 in the auditorium of the National Academy of Sciences Bldg., Washington, D.C.

The Conference is sponsored by the Baltimore-Washington Section of the Society of Plastics Engineers, Inc. in cooperation with the Prevention of Deterioration Center, National Academy of Sciences.

Purpose of the Conference is to discuss and explore current concepts of mechanisms governing natural and synthetic polymer stability and degradation. Subjects to be covered include degradation under conditions of mechanical processing, ultraviolet or other radiational exposure, elevated temperatures and enzymatic attack.

Engineers

M. M. Anderson has been named vice president — engineering, Stran-Steel Corp.

I. O. Johnson has been appointed director of industrial and production engineering, Fulton Sylphon Div., Robertshaw-Fulton Controls Co.

Harold Weiss has been named to the newly established position of manager of applications engineering, Computer Dept., General Electric Co.

Murray T. Stewart is now a member of the special high temperature al-

Spaulding FIBRE FACTS FOR ENGINEERS NUMBER 2

THE USES OF VULCANIZED FIBRE'S INHERENT TOUGHNESS

by Earl A. Russell, Chief Engineer, Spaulding Fibre Company, Inc.

The toughness of Vulcanized Fibre often contributes uniquely to meeting crucial requirements of an application as well as to making possible low cost fabrication. For example a vulcanized fibre kickback plate in a bowling alley makes effective use of its built-in toughness while in an automobile starter switch the toughness of fibre permits swaging a supporting bushing to fit the switch case.

What die casting does in reducing the cost of odd shaped parts in metals, swaging does with vulcanized fibre. In addition to being tough enough to readily withstand punching operations, it is also sufficiently plastic to permit swaging to shape. In this particular swaging operation the fibre is compressed in some areas and flowed into raised areas to form a shank fitting into the hole and a shoulder fitting the contour of the starter switch case (Fig. 1).

In the assembly the sturdy switch contacts are economically mounted and fully insulated with vulcanized fibre, taking advantage of the toughness of the fibre parts to provide adequate support against the impact of entering switch contacts.

It may be noted further that combined with the toughness to withstand punching and the plasticity to permit swaging into low cost parts, vulcanized fibre provides the required electrical insulation.

In the bowling alley application (Fig. 2) wood could not take the beating from the pounding blows of the pins as they smash against the partitions that separate the alleys. For protection of the wooden partition, the toughness of vulcanized fibre is required to withstand the repeated blows from the pins. At the same time the fibre must be sufficiently plastic to avoid damaging the pins yet resilient enough to provide acceptable rebound for desirable pin action.

Fibre performs these unusual functions through years of service at surprisingly low cost.

In railroad track insulation, athletic protective parts, gaskets for high pressure systems, switch parts, electric motor parts and formed parts for many applications, the toughness of fibre combines with other important properties to provide a simple part which performs two or more functions with good results and low cost.

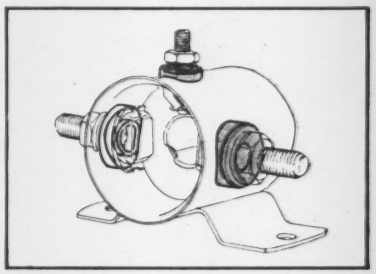

FIGURE 1. A complex shape difficult to machine by ordinary methods, this vulcanized fibre bushing is swaged and punched in one operation to produce a low cost part to meet strict requirements of toughness. Supporting heavy duty contacts under repeated shock loads, the bushing also insulates the contacts against the surrounding case.

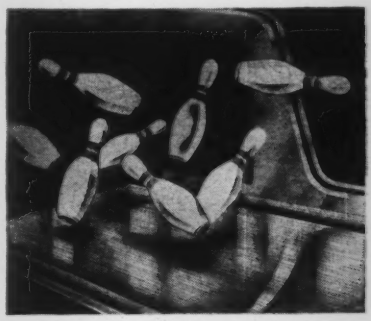

FIGURE 2. Tough vulcanized fibre kickback plate absorbs the impact of the flying pin without damage to the pin or the partition. The rebound action, so necessary to top scores, is possible because of the resiliency of the fibre.

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THE MEARL CORPORATION
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News OF INDUSTRY

loys section, Research Laboratory, International Nickel Co.

Harold H. White has been named director, blasting practices and explosives research, Vulcan Materials Co., Birmingham, Ala.

George F. Halfacre has been elected vice president in charge of manufacturing, New Jersey Zinc Co.

John R. Bossenga has been named assistant to the chief engineer, **Ernie C. Rangus** has been named production and tooling engineer, and **Gediminas Bubelis** has been appointed chief craftsman, Engineering Dept., SpeedWay Mfg. Div., Thor Power Tool Co.

Robert A. Barr has been appointed general manager, Refractories Div., Babcock & Wilcox Co.

Dr. Charles L. McCabe has been named head of Carnegie Institute of Technology's Department of Metallurgical Engineering.

Charles E. DeMars has been named plant engineer, Tranter Mfg., Inc., Lansing, Mich.

Dr. Kenneth J. Radimer is now research chemist, M. W. Kellogg Co., a subsidiary of Pullman, Inc.

Earl S. Evans has been named assistant chief engineer, Steam Turbine Dept., Allis-Chalmers Mfg. Co.

Fred A. Brinker has been appointed general manager, Western Div., Vanadium Corp. of America.

Kenneth A. Morris has been named production control manager, Elgin Metalformers Corp.

Paul S. Nurko has been named works manager, De Laval Steam Turbine Co.

Kalman Rusinow is now project engineer, Microwave Dept., Central Electronic Mfrs., a division of Nuclear Corp. of America.

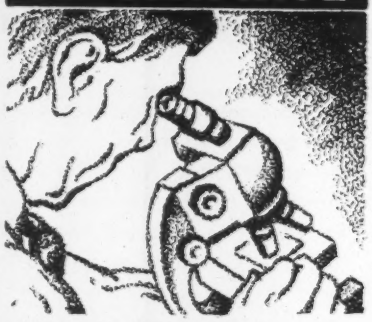
Wilbur E. Lunger has been elected staff vice president of manufacturing, and **H. Ben Young** has been elected staff vice president of engineering and research, ACF Industries, Inc.

Norman D. Groves and **Neil J. Culp** have been appointed assistant managers of research in charge of chemistry and physics, respectively, Metallurgical Dept., Carpenter Steel Co.

Peter Leckie-Ewing has joined the metallurgical staff of Latrobe Steel Co.

Frederick A. Fielder has been appointed vice president and general

Let Us Help You Pioneer New Uses For GRAPHITE



GRAPHITE is the most economical material that combines—

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— and other distinctive chemical and physical characteristics.

GRAPHITE is the most economical material suitable for such applications as—

- Permanent molds for metal castings
- Other molds and crucibles
- Brazing fixtures
- Forms for heat treating
- Extrusion run-out tables
- Rocket nozzles

If you have a design engineering problem that graphite might help solve, call upon the assistance of our well-qualified graphite specialists. They will be glad to help with your problem.

ELECTRODE GLC DIVISION

GREAT LAKES CARBON CORPORATION
18 EAST 48TH STREET
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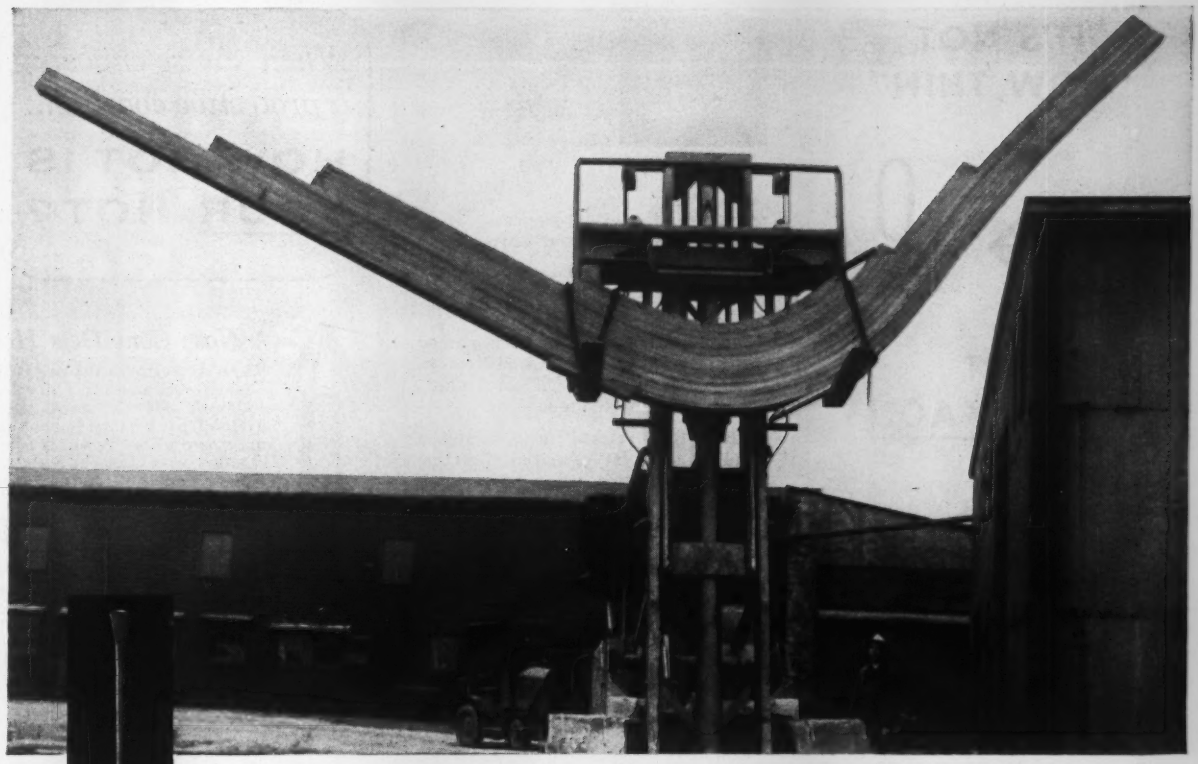
GRAPHITE SPECIALTIES IN PLATES, BARS AND ROUNDS.

For more information, circle No. 410



from paddles...to gunboat stems...

GAMBLE solves problems with WOOD!

The armed forces' solid wood life raft paddles often shattered when dropped from a plane, or splintered when used to "pry" a landing craft onto a beach. Then Gamble Brothers developed a paddle with a shatterproof laminated blade and a dense hardwood handle. Result: a stronger, lighter paddle made with less waste of wood.

The gunboat stem problem was different. Wood, as a non-magnetic material, was specified. But who could engineer and fabricate curved sections of such great cross-sectional depth and width? The answer again: Gamble Brothers, by built-up laminations.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers—a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4627 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS GB GUARANTEED BOND

GAMBLE BROTHERS, INC.

4627 Allmond Avenue, Louisville, Kentucky

For more information, turn to Reader Service card, circle No. 392

For more information, circle No. 460

IT'S NOT
"HOW THIN"

→ 0/8

BUT
HOW EXACT!

With the recent trend in strip metal towards thinner and thinner gauges, Somers, a pioneer in thin strip for nearly 50 years, is naturally among the leaders in rolling *ultra-thin* strip. But in addition to rolling production quantities of strip as thin as can be obtained anywhere in the world, Somers utilizes exclusive techniques and equipment to make sure that every foot of metal is up to the most exacting standards.

1. Accu-Ray nuclear gauging to assure absolute uniformity of thickness throughout.

2. Unique rolling mill for strip from .001" down, makes possible extremely close control of the final pre-anneal temper, and uniform accuracy of the final temper.

3. Experience exclusively with thin strip metals gives Somers an unmatched background in engineering *ultra-thin* strip to meet all special requirements.

NEARLY
FIFTY
YEARS

FOR EXACTING STANDARDS ONLY
Somers

Somers Brass Company, Inc.
108 BALDWIN AVE., WATERBURY, CONN.

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News OF INDUSTRY

manager, Loewy-Hydropress Div., Baldwin-Lima-Hamilton Corp.

Edward A. Margus has been named assistant director of product engineering, Cooper Alloy Corp.

Thaddeus J. Kusto has been named director of research, and **Milton M. Gerber** has been named chief engineer, Computer Systems, Inc.

Walter R. Derlacki has been appointed assistant research director, Luria Bros. & Co., Inc.

Michael Zara has been appointed production control manager, Servo Corp. of America.

B. R. McBath is now general manager, Plainfield Div., Worthington Corp.

Robert W. Pressing has been appointed general manager, New Products Dept., Linde Co., a division of Union Carbide Corp.

Thomas J. McDonough, Jr., has been named assistant superintendent, Coarse Wire Dept., Prentiss Wire Mills, Riverside-Alloy Metal Div., H. K. Porter Co., Inc.

Charles H. Creasser has been appointed vice president in charge of manufacturing, Walworth Co.

Dr. Jane Connor has been named research project leader, Evans Research & Development Corp.

A. R. Hughes has been named to the newly created position of special projects engineer, Fischer & Porter Co.

William C. Benson has been appointed project engineer, ground support equipment, Solar Aircraft Co.

Dr. Paul H. Lindenmeyer is now research scientist, Chemstrand Corp.

R. J. McIntosh has been named plant manager, Structural Steel Mfg. Div., R. C. Mahon Co.

Cornelius S. Kipfer has been appointed superintendent, central shops, Argonne National Laboratory.

Roger C. Waugh is now project engineer for industrial fuels, M & C Nuclear, Inc., a subsidiary of Texas Instruments Inc.

William F. Hurst has been named director of quality control, Inet Div. and Special Products Div., Leach Corp.

Raymond Letner, Melpar, Inc., a subsidiary of Westinghouse Air Brake Co., is the recipient of a National Bureau of Standards award for the

For more information, circle No. 405

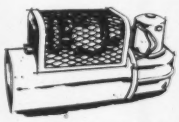
When you're choosing a protective coating...

HOW HOT IS
YOUR HOT?

A Nose Cone Gets Hot

When conventional organic finishes were used in Chrysler Redstone Missile tests, they ignited and disintegrated under simulated re-entry conditions. Sicon survived because it possessed the inherent heat resistance to meet performance requirements. This has been confirmed in large scale tests and actual missile firings.

A Truck Heater Gets Hot



A porcelain type coating used on a truck heater failed because it could not stand the thermal shock of rapid heating and cooling. The same heating (550°-600°F.) and cooling left Sicon's film integrity unaffected.

A Tractor Engine Gets Hot

A farm equipment manufacturer used a bright organic red color on their standard equipment. The coating on the engine parts, which were subjected to high temperature, quickly decomposed. Midland engineers developed a matching bright Sicon Red which retained its color and gloss and protected the hot spots on the engine.

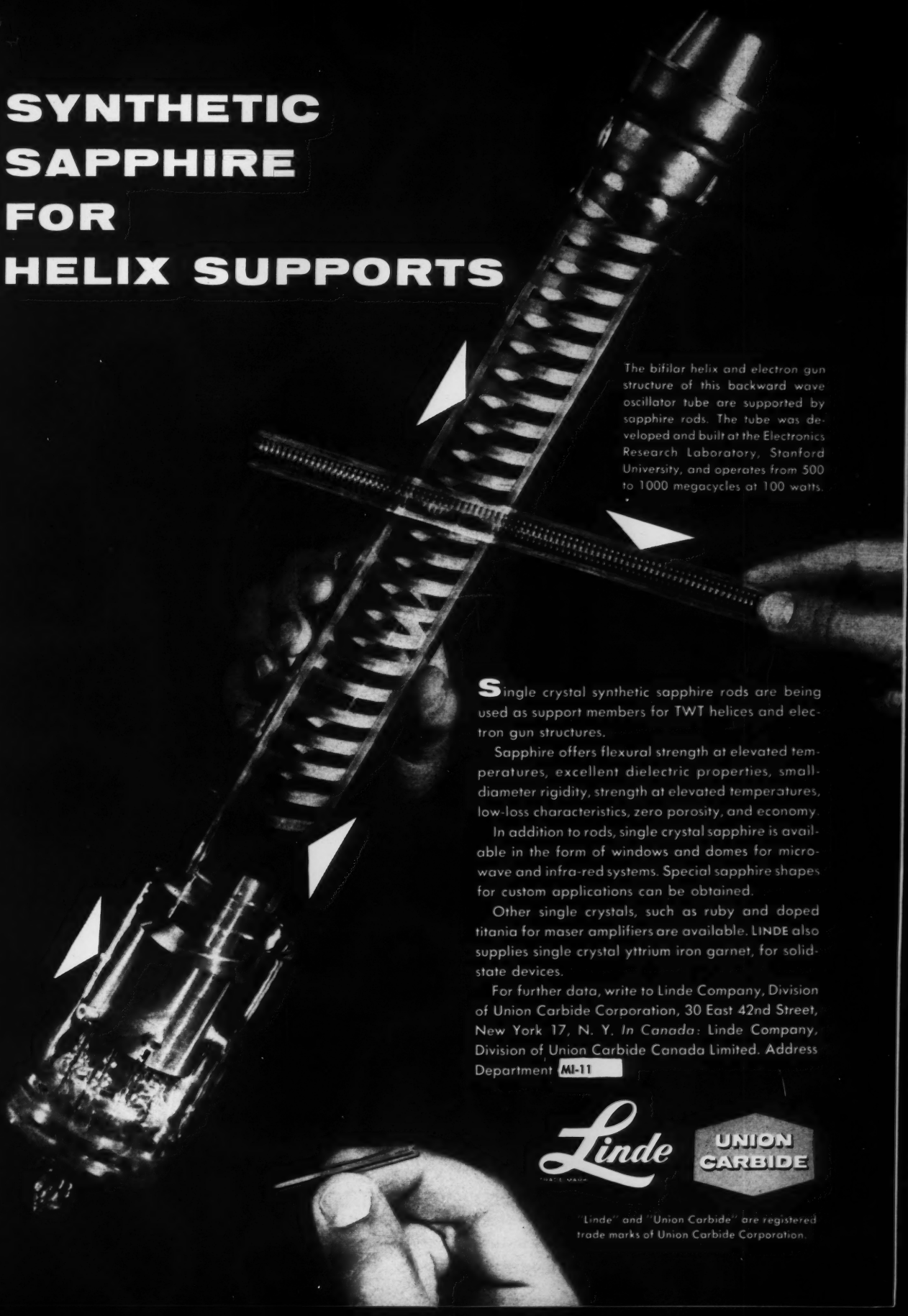
How HOT is your HOT?

Sicon possesses the flexibility of ordinary organic finishes and the heat resistance of ceramic coatings—up to 1000°F. in black or Aluminum; up to 550°-600°F. in decorative colors. Upon inquiry a sample Sicon formulation for testing your "hot" requirements will be prepared at no obligation. Send details of your "hot spot" problem today to Dept.1-K.

Sicon®
HEAT RESISTANT FINISH
A Silicone Product of

MIDLAND
INDUSTRIAL FINISHES COMPANY
WAUKEGAN · ILLINOIS
ENAMELS · SYNTHETICS · LACQUERS · VARNISHES

SYNTHETIC SAPPHIRE FOR HELIX SUPPORTS



The bifilar helix and electron gun structure of this backward wave oscillator tube are supported by sapphire rods. The tube was developed and built at the Electronics Research Laboratory, Stanford University, and operates from 500 to 1000 megacycles at 100 watts.

Single crystal synthetic sapphire rods are being used as support members for TWT helices and electron gun structures.

Sapphire offers flexural strength at elevated temperatures, excellent dielectric properties, small-diameter rigidity, strength at elevated temperatures, low-loss characteristics, zero porosity, and economy.

In addition to rods, single crystal sapphire is available in the form of windows and domes for microwave and infra-red systems. Special sapphire shapes for custom applications can be obtained.

Other single crystals, such as ruby and doped titania for maser amplifiers are available. LINDE also supplies single crystal yttrium iron garnet, for solid-state devices.

For further data, write to Linde Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada*: Linde Company, Division of Union Carbide Canada Limited. Address Department MI-11

Linde UNION CARBIDE

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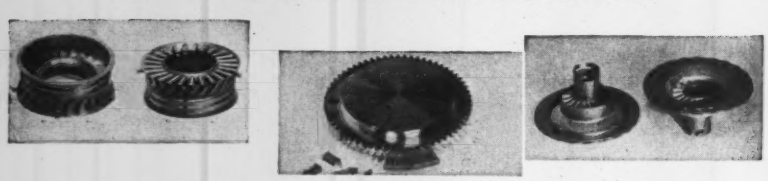
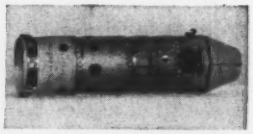
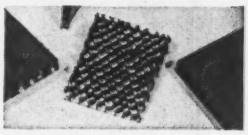


We Furnace Braze Stainless Alloys

To eliminate problems of distortion, stress, oxidation, and porous welds

The advantages of stainless alloy brazing in dry hydrogen or vacuum environment furnaces are many. And the use of brazing for high-temperature service parts is growing just as fast as potential users learn to design for it. We offer technical design assistance to further the acceptance of this modern joining technique. Ten years of pioneering this field, plus operating three stainless processing plants, plus manufacturing our own Nicrobraz® brazing alloys, fully qualifies us to give initial guidance to your design crew in planning brazed stainless components. Call TWinbrook 3-3800 in Detroit, or write to find out how we might help you.





STAINLESS PROCESSING DIVISION
WALL COLMONOY CORPORATION
19345 John R Street • Detroit 3, Michigan
There are Wall Colmonoy furnace plants in Detroit, Michigan; Morrisville, Pennsylvania; and Montebello, California

custom molders
of **FIBERGLASS**
reinforced polyester

Your product, in whole or in part, may be ideally suited for adaption to an incredibly strong, amazingly lightweight, beautifully textured Lewis one piece molding.
Let our experienced plastic engineering staff study your product, whether it be in existence, or still in blueprint form.

√ MOLDED-IN COLORS √ WON'T ROT OR RUST √ LIGHTER THAN ALUMINUM
√ STRENGTH LIKE STEEL √ CHEMICAL RESISTANT √ SOUND DEADENING

Fiberglass reinforced plastics stimulate fresh, modern style appeal... and are exciting new sales potentials to a wide variety of consumer and industrial products. And no wonder, for the outstanding physical characteristics of this basic new material, plus its many profitable production advantages, create great interest and impact everywhere. Dimensional stability... chemical resistance... tolerance to temperature extremes... rust-proof, rot-proof, corrosion-proof... and a limitless variety of lasting colors molded-in for life... all these benefits, and many more, are to be found with Lewis reinforced polyester moldings.

More and more leading manufacturers are depending on Lewis for quality reinforced plastic moldings. Our trained engineers are ready to assist you in converting your product to this new material.

G. B. LEWIS COMPANY
Department MS • WATERTOWN, WISCONSIN

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development of a unique welding method.

William F. Newbold has been appointed director of research, Brown Instruments Div., Minneapolis-Honeywell Regulator Co.

Edward L. Badwick has been named plant manager of Accurate Specialties Co., Inc.'s new semiconductor component plant in Hackensack, N. J.

F. L. Green has been appointed chief product design engineer, Prescolite Mfg. Co., Berkeley, Calif.

Companies

Digital Instrument Laboratories has moved to a new plant at 5115 Via Corona, Los Angeles.

DEK Industries, Inc. has acquired **Rolle Mfg. Co.,** which will be operated as a wholly-owned subsidiary of DEK.

Cee-Bee Chemical Co., Inc., Downey, Calif., has formed a new Missile, Nuclear & Rocket Div.

Artloom Industries, Inc. has purchased **Eastern Precision Resistor Corp.**

Dow Metal Products Co. is a newly formed division of Dow Chemical Co.

ThermoTextiles, Inc., P. O. Box 75, Gastonia, N. C., is a new textile manufacturing company.

Bellows Co. Div., International Basic Economy Corp., has purchased **Jackson Electronic & Mfg. Co.,** Akron, Ohio.

Melpar, Inc. will build a 120,000-sq ft addition to its plant in Falls Church, Va.

Industrial Plastic & Equipment Co., Inc. has moved to larger quarters at 173 Main St., Orange, N. J.

Presstite Div., American-Marietta Co., is the new name for **Presstite-Keystone Engineering Products Co.**

Solar Engineering Corp. is a new engineering and design firm located at 2141 Hilton Rd., Detroit, Mich.

Ideal Precision Meter Co., Inc. has acquired a new plant at 214 Franklin St., Brooklyn, N. Y.

Telemeter Magnetics, Inc. has acquired **Invar Electronics Corp.,** 323 W. Washington Blvd., Pasadena, Calif.

McNeil Laboratories, Inc. has begun construction of a multi-million-dollar

CLINCO

EPOXY COMPOUNDS

The Most Complete Quality Line...

from a long established, reliable, centrally located Chicago manufacturer

CLINTON offers a full series of special epoxy formulations developed to meet the growing list of applications for this versatile material in almost every field of manufacturing—from rockets to radio parts. All are available in bulk quantities . . . a few of the more popular compounds are listed below:

2-C-202 High Heat Distortion, Hard, Abrasion Resistant Casting Compound.

Suggested Uses: 1—Dies. 2—Jigs. 3—Fixtures where high heat distortion, good hardness, and abrasion resistance are needed, and oven-curing facilities are needed. It can also be used for Casting Pipe Fittings.

2-C-204 Room Cure Casting Compound for Thick Sections.

Suggested Usage: A Room Cure Casting Compound for Jigs, Fixtures, Dies, Core Boxes, etc.

2-C-208 Casting and Sealant Compound.

Used for small Castings which require Electrical Conductivity. This formula has 5,000 to 18,000 ohms/inch resistance.

This material can be used as a solder for electrical connections.

2-C-214 Molding and Extrusion Compound.

Suggested Uses: Injection Molding Electrical Parts, Pipe, and many other types of Molding applications. This formula can also be extruded successfully.

2-C-215 Encapsulating Compound.

Suggested Use: For encapsulating any electrical component to give it electrical insulating resistance.

2-C-217 Protective Coating for Coil Wire.

Suggested Uses: For coating electrical wires and coils. May also be dip-coated.

2-C-218 Tube Sealing Compound.

Suggested Uses: To be used as a sealing compound for sealing ends of Capacitators and Tube Sockets. This formula is resilient and can be used where thermal expansion is a problem in Capacitators.

2-C-243 Potting Compound.

Suggested Uses: For potting of electrical components such as filter networks, audia stages, etc. This material is poured around the form to be potted.

2-C-227 White Sprayable Surface Coat.

Suggested Use: To be sprayed on the inside of a mold upon which a mold-release agent has been applied.

It is also used by brushing layer upon layer on fibre glass to build up a desired thickness, curing each coat as you go along.

This can be supplied in a variety of colors.

2-C-239 Tile Cement—Chemical Resistant Sealer for space between Tiles.

Suggested Uses: To fill space between tiles in order that the surface will have excellent chemical resistance.

2-Y-127 Concrete Floor Patching Compound.

Suggested Use: For repairing Concrete at heavy wear points.

2-C-409 Masonry Waterproofing Compound.

Suggested Use: Waterproofing material, such as on basement walls, on exterior masonry surfaces, both for decorative purposes (when supplied in pigmented form) as well as for waterproofing purposes. Cinder block wall construction may be used on a large scale with full protection provided by this liquid epoxy coating.

2-C-236 Boat Patching and Repair Laminating Compound.

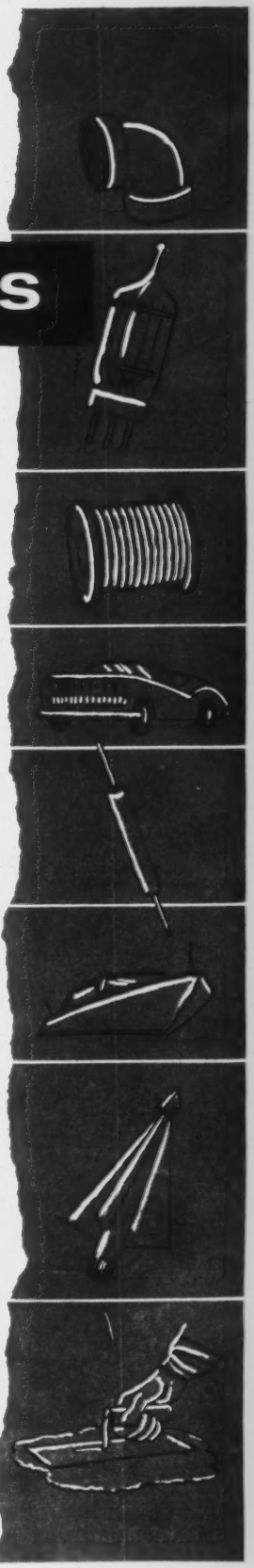
Suggested Uses: As mentioned above, it can be used for repairing or covering wood or metal boats and automobile bodies.

2-C-195 General Purpose Adhesive.

Suggested Uses: Bonding metal to metal, wood to wood, plastic to plastic, etc.

2-C-199 Flexible Room-Cure Adhesive.

Suggested Uses: For bonding flexible surfaces to flexible surfaces.



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THE CLINTON COMPANY

Pioneering Quality Industrial Finishes Since 1928

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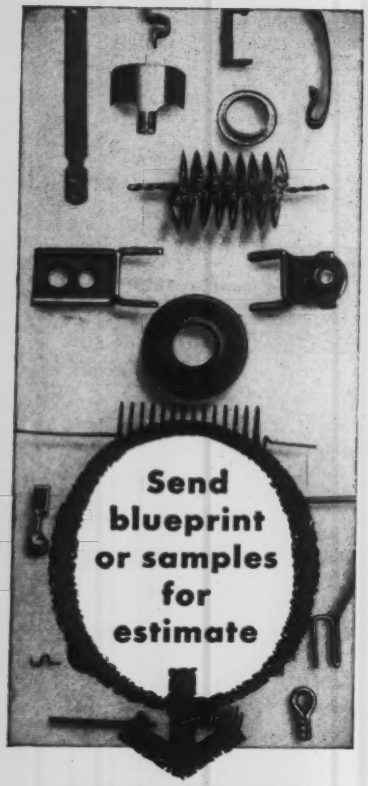

WIRE FORMS
and
METAL STAMPINGS

We'll prove that our high speed production means lower unit costs for you!

You'll save two ways — (1) the initial low unit cost made possible by high speed machines; (2) precision and quality control guarantees accurate parts and performance.

STRAIGHTENING AND CUTTING
Perfect straight lengths to 12 feet.
.0015 to .125 diameter.

WIRE FORMS
.0015 to .125 diameter.

SMALL METAL STAMPINGS
.0025 to .035 thickness.
.062 to 3 inches wide.

Specializing in production of parts for electronic, cathode ray tubes and transistors.

Write for illustrated folder.

ART WIRE AND STAMPING COMPANY

13 Boyden Place, Newark 2, N. J.

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News OF INDUSTRY

plant in Whitemarsh Township, near Philadelphia.

Lear, Inc. has dedicated its new $5 million instrument manufacturing facility in Grand Rapids, Mich.

Parker Aircraft Co. has broken ground for a new building to be located at 5827 W. Century Blvd., Los Angeles.

Glamorgan Pipe & Foundry Co., Lynchburg, Va., has formed a new Plastics Div. to manufacture rigid polyvinyl chloride pipe.

Eutectic Welding Alloys Corp. has begun construction of a new metallurgical center in St. Sulpice, Switzerland.

United Shoe Machinery Corp.'s Research Div. has formed an Advanced Development & Systems Dept.

American-Marietta Co. has purchased **Concrete Materials & Construction Co.** of Cedar Rapids, Iowa.

Master Mechanics Co. has begun construction of a new plant, office and research center on Miles Ave. at E. 175th St., Cleveland.

Foote Mineral Co. has broken ground for the construction of a $2.2 million research and engineering building near Exton, Pa.

Oronite Chemical Co., San Francisco, has formed a new Commercial Development Dept. as part of a major expansion and reorganization program.

Electric Storage Battery Co. has purchased **Wisconsin Storage Battery Co.**, which will become part of ESB's Automotive Div.

Precision Extrusions, Inc., Bensenville, Ill., has established a new office at 6216 Carrollton Ave., Indianapolis.

Monsanto Chemical Co. plans to build a research center in St. Louis.

Victoreen Instrument Co. has acquired **Standard Felt Co.** of Alhambra, Calif.

Allis-Chalmers Mfg. Co. has formed a value analysis section with D. O. Millar named engineer-in-charge.

Micrometrical Mfg. Co. has begun construction of new facilities to accommodate all manufacturing, engineering and research activities at 3621 S. State Rd., Ann Arbor, Mich.

Scientific Glass Apparatus Co., Inc. has built a new branch plant in Centex Industrial Park, Elk Grove Vil-

WANTED: a new use for a new material

ZEVESCAL®

Zevescal, a patented wear-resistant alloy is producing exceptional wear life in cast parts for equipment such as

SCREW CONVEYORS • FRIT CRUSHERS
IMPACT CRUSHERS • SAND SLINGERS
SHOTBLAST MACHINES • BALL MILLS
HYDRAULIC DREDGES • GRINDERS
• HAMMER MILLS

Tell us how you think you could use ZEVESCAL for applications requiring optimum resistance to wear. We will be glad to send a sample for testing in your own product or process.

CALUMET STEEL CASTINGS CORPORATION

Manufacturers of Carbon, Alloy, Heat, Wear and Corrosion-Resistant Electric Furnace Steel Castings

1606 SUMMER STREET • HAMMOND, INDIANA

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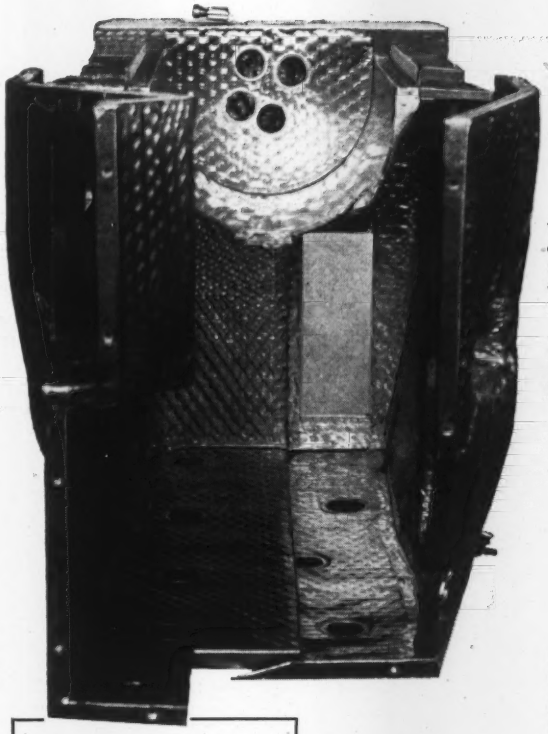
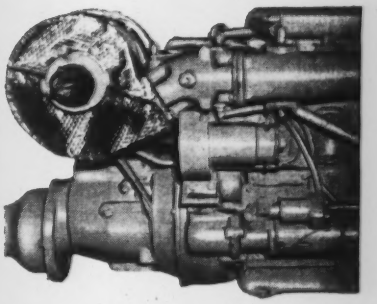
Johns-Manville PRE-KLAD insulations are made possible through the company's extensive experience in fabrication and forming of thin foils.



This typical PRE-KLAD insulated housing features combination of molded parts, strengthened channel construction, close tolerance cut-outs to accommodate fittings and attachments.

Now—insulate difficult shapes in one fast operation . . .



PRE-KLAD as used by diesel engine manufacturers. Here, J-M engineers worked with customer's engineers to develop insulated blankets that readily slip over turbochargers to protect personnel and keep engine room temperature down.

Among the many PRE-KLAD applications

- Gasoline Engines
- Gas Turbine Engines
- Steam Turbines
- Heated Mechanical Equipment
- Domestic and Industrial Furnaces
- Stress Relieving Blankets
- Ingot Pads
- Heated Laboratory Equipment
- Diesel Engines, Manifolds, Turbochargers
- Home Incinerators, and other Hot Appliances
- Portable Heat Retention Equipment
- Turbogenerators
- Materials Handling Equipment
- Gear Housings
- Removable Casting and Forging Covers
- Furnace Nozzle Cones

with Johns-Manville PRE-KLAD Insulation!

New refractory fiber insulation is factory sheathed in heat-resistant foils to any required shape . . . temperatures to 2000F!

In new PRE-KLAD insulation, designers have an insulation that's right in step with efficient assembly line methods. For PRE-KLAD components arrive at your plant ready to install . . . in one fast operation!

Originally developed for jet aircraft . . . PRE-KLAD insulations are precision engineered to solve individual heat retention problems. Johns-Manville tool engineers create the special molds and dies to form the stainless steel or other thin foils into the shape you require. Then, refractory felt insulation is expertly sandwiched between inner and outer foil jackets, which are then spot- or seam-welded into a ready-to-install housing or blanket. The result is an insulating component that can be used wherever a strong, lightweight foil-protected insulation is indicated.

The insulation in PRE-KLAD is Johns-Manville CERAFELT® . . . a refractory fiber insulation that is produced by converting molten refractory materials into a mass of uniform ceramic fibers. The fine CERAFELT fibers are then felted with a minimum of binder to form an insulating material that combines lightness, heat resistance and an extremely low *k* factor.

Write today for the informative new brochure on PRE-KLAD insulations.
Address Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ont.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

For more information, turn to Reader Service card, circle No. 501

CHR

COHRlastic R-10470

Silicone Sponge Rubber

Flexible at extreme temperatures
−100°F to 500°F

COHRlastic R-10470 has a dense, uniform, non-absorbing closed cell structure. It has superior compression set, excellent dielectric properties, immunity to aging, ozone and weather, good chemical resistance and is odorless, non-corrosive, non-sticking.

COHRlastic R-10470 can be bonded to metals, plastics, fabrics or silicone rubber. Ideal for gasketing, vibration damping, fairing strips, seals, pads, bumpers, cushions and other applications where resiliency at high or low temperatures is required.

Available from distributor stock: sheets 24" x 24" and in thicknesses 1/16" through 1/2". Larger sizes and special molded and extruded shapes made to order.

COHRlastic R-10470

TYPICAL PROPERTIES

Tensile	50-130 psi
Elongation	175-225%
Water absorption *(Immersion 24 hrs. @ 75°F.)*	3-6%
Density, lbs./cu. in.	.020-.030 (firm) .013-.018 (medium)
Low temperature brittleness *(5 hrs. @ −100°F., bend flat)*	No cracking
Compression deflection *(compressed to 75% of original thickness)*	
Room temperature	
Type firm	12-18 psi range[1]
Type medium	8-14 psi range[1]
−65°F. pct. difference	−10% to +15%[1]
212°F. pct. difference	+ 5% to +10%[1]
Compression set *(compressed to 50% of original thickness)*	
22 hrs. @ 70°F.	0-5% (firm)[1] 5-30% (medium)[1]
22 hrs. @ −65°F.	0-5% (firm)[1] 5-30% (medium)[1]
22 hrs. @ 212°F.	10-25% (firm)[1] 20-50% (medium)[1]

[1] ASTM D1056-56T

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News OF INDUSTRY

lage, Ill. John F. Green has been appointed general manager of the new division.

Pressure Blast Mfg. Co., Inc., Manchester Conn., has purchased **Sand Blast Equipment Div.**, Leiman Bros. Co., Inc.

Minneapolis-Honeywell Regulator Co. has consolidated its control devices and machine controls departments to form a new Industrial Controls Div.

National-U.S. Radiator Corp. has purchased **Magnetic Powders, Inc.**, and will operate it as a wholly-owned subsidiary.

Centrifugal Casting Co. has moved to 17 W. 60th St., New York 23.

Universal Grinding Corp. has begun a 27,000-sq ft expansion of its plant at 2200 Scranton Rd., Cleveland.

Handley, Inc. has moved its engineering department and manufacturing plant to 12964 Panama St., West Los Angeles.

Virginia-Carolina Chemical Corp. will construct a contact sulfuric acid plant at Nichols, Fla.

Societies

American Society for Metals has elected the following officers: president—Walter Crafts, Union Carbide Metals Co.; vice president—William A. Pennington, University of Maryland; treasurer—Robert J. Raudebaugh, International Nickel Co.; and secretary—Walter E. Jominy, Chrysler Corp.

Pressed Metal Inst. and Worcester Pressed Steel Co. have announced Federico Strasser of Santiago, Chile, as the winner of the 1959 Presteel Award in recognition of "a substantial contribution to enlarging the field of metal stampings."

Powder Metallurgy Parts Mfrs. Assn. has elected the following companies to its membership: Elco Sintered Alloys Co., Inc.; Symmco, Inc.; and Parker White Metal Co.

Metallurgical Society, American Inst. of Mining, Metallurgical, and Petroleum Engineers, has announced the following 1960 officers: president—Dr. Carleton C. Long, St. Joseph Lead Co.; vice president and president-elect —J. S. Smart, Jr., American Smelting & Refining Co.

American Die Casting Inst. has elected the following officers: president—Gordon C. Curry, Dollin Corp.;

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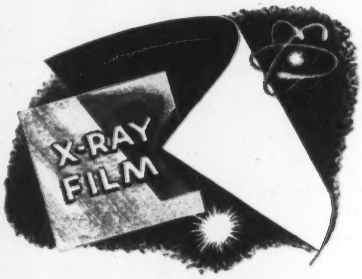

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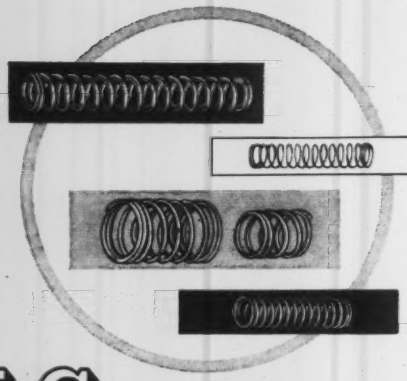

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News OF INDUSTRY

vice president—Walter E. Brown, Kiowa Corp.; secretary — David Laine; and treasurer—W. J. Parker.

American Electroplaters' Society, Inc., has named Dr. A. Kenneth Graham of Graham, Savage & Asso. winner of the Society's Scientific Achievement Award.

Meetings

STEEL FOUNDERS' SOCIETY OF AMERICA, 14th technical and operating conference. Cleveland. Nov 9-11.

AMERICAN SOCIETY OF INDUSTRIAL DESIGNERS, meeting on "Planning by Design—In a World of Product Change." New York City. Nov 12-13.

5TH CONFERENCE ON MAGNETISM AND MAGNETIC MATERIALS, American Inst. of Electrical Engineers; Office of Naval Research; Metallurgical Society of AIME; American Physical Society; and Inst. of Radio Engineers. Philadelphia. Nov 16-20.

EASTERN DIV., SOCIETY OF AIRCRAFT MATERIALS AND PROCESS ENGINEERS, fall meeting. Washington, D. C. Nov 17.

17TH ELECTRIC FURNACE STEEL CONFERENCE, American Inst. of Mining, Metallurgical, and Petroleum Engineers. Cleveland. Dec 2-4.

TREATMENTS AND FINISHES FOR AEROSPACE MATERIALS Conference, American Electroplaters' Society and Southwest Society of Aircraft Materials and Process Engineers. Fort Worth, Tex. Dec 8-9.

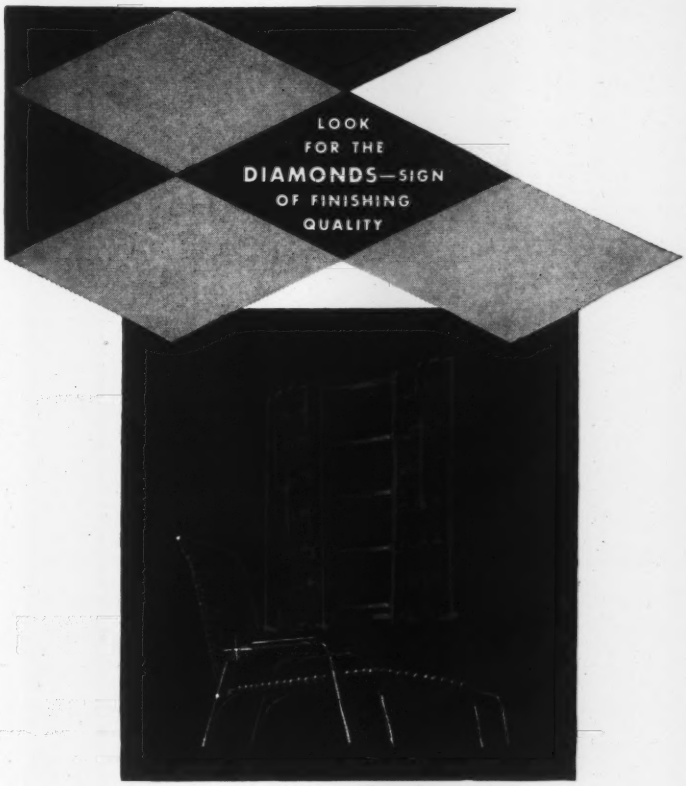
2ND NATIONAL CONFERENCE ON THE APPLICATION OF ELECTRICAL INSULATION, American Inst. of Electrical Engineers and National Electrical Mfrs. Assn. Washington, D. C. Dec 8-10.

6TH NATIONAL SYMPOSIUM ON RELIABILITY AND QUALITY CONTROL, Inst. of Radio Engineers, American Society for Quality Control, Electronic Industries Assn., and American Inst. of Electrical Engineers. Washington, D. C. Jan 11-13.

SOCIETY OF PLASTICS ENGINEERS, INC., 16th Annual National Technical Conference. Chicago. Jan 13-15.

MALLEABLE FOUNDERS SOCIETY, semi-annual meeting. Cleveland. Jan 15.

SOCIETY OF VACUUM COATERS, 3rd annual meeting. New York City. Jan 26-27.



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Wiley BOOKS

1. THE NATURE AND PROPERTIES OF ENGINEERING MATERIALS

By Z. D. JASTRZEBSKI, *Lafayette College.* Much more basic than the usual treatment, this stresses materials from the engineering viewpoint, with realistic applications. Emphasis is on concepts of solid state science and the chemistry, metallurgy, and mechanics necessary for a good basic understanding of engineering materials. Future technological developments are considered as well as present applications. *1959. 571 pages. Prob. $11.00*

2. PROPERTY MEASUREMENTS AT HIGH TEMPERATURES

Edited by W. D. KINGERY, *M.I.T.* The first to cover thoroughly high-temperature materials and property measurements above 1400°C (2550°F). For researchers: available data, their reliability, and measurement methods. For materials developers: high-temperature systems and variables affecting properties. For users: present status of high-temperature measurement and data on properties of materials. *1959. 416 pages. $16.50*

3. FOUNDRY ENGINEERING

By HOWARD F. TAYLOR, MERTON G. FLEMINGS, *and* JOHN WULFF, *all of M.I.T.* A thoroughly modern approach to this 3500-year-old art and science, covering principles and methods of today's materials and processes in foundry operation. The elements covered here apply to all cast metals. Includes: casting processes; the nature of cast metals; risering; gating; casting defects; inspection and repairs; sands; heat treatment of cast metals—and many other factors. *1959. 408 pages. $9.75*

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TECHNICAL LITERATURE

(cont'd from p 45)

Books

The Properties of the Rare Earth Metals and Compounds. *Compiled by J. A. Gibson, J. T. Miller, P. S. Kennedy and G. W. P. Rengstorff. Battelle Memorial Institute, Columbus, Ohio. Paper, 9 by 11 in., 214 pp. Price $10*

This book brings together all available information on the properties of rare earth metals and their compounds. Included are the physical, crystal, chemical, mechanical, electrical, magnetic, nuclear and thermodynamic properties of the rare earth metals: cerium, praseodymium, neodymium, promethium, lanthanum, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium. Properties are also given for yttrium. The book contains phase diagrams.

Symposium on Materials Research Frontiers. *ASTM STP No. 248. American Society for Testing Materials, Philadelphia. 1959. Cloth, 6 by 9 in., 48 pp. Price $2*

Subjects discussed include: 1) tailoring the properties of materials; 2) materials in the nuclear age; 3) modern liquid fuels; 4) new advances in physical metallurgy; and 5) recent developments in glass research.

Corrosion and Deposits in Boilers and Gas Turbines. *American Society of Mechanical Engineers, New York. 1959. Paper, 8½ by 11 in., 198 pp. Price $6*

Discusses factors that cause destruction of boilers and gas turbines such as mineral and ash forming constituents in coal and fuel oil, and oxides of sulfur in boilers and gas turbines. Information on high temperature corrosion, and on corrosion of metals exposed to combustion gases below 400 F.

The Sequestration of Metals. *Robert L. Smith. Macmillan Co., New York. 1959. Cloth, 6 by 10 in., 264 pp. Price $8.50*

Gives chemical and physical properties of sequestering agents, and discusses the use of these materials in treating metals, plastics, rubber, paper textiles and leather.

ASTM Proceedings: Volume 58. *American Society for Testing Materials, Philadelphia. 1959. Cloth 6 by 9 in., 1420 pp. Price $12*

Includes committee reports on ferrous and nonferrous metals, ceramics, paints, wood and paper. Also includes technical papers on fatigue and crack propagation.

Technology of Printed Circuits. *R. Eisler. Academic Press Inc., New York. 1959. Cloth, 5¼ by 8¾ in., 415 pp. Price $12*

Information on the design, production and use of printed circuits. The book contains seven appendixes and a bibliography with 481 entries.

Basic Engineering Metallurgy: 2nd Edition. *Carl A. Keyser. Prentice-Hall, Inc., New York. 1959. Cloth, 6 by 9 in., 517 pp. Price $8.50*

Properties and uses of such metals as iron and its alloys, aluminum, magnesium, cop-

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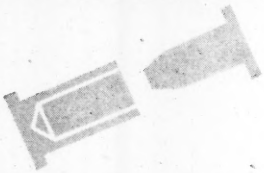

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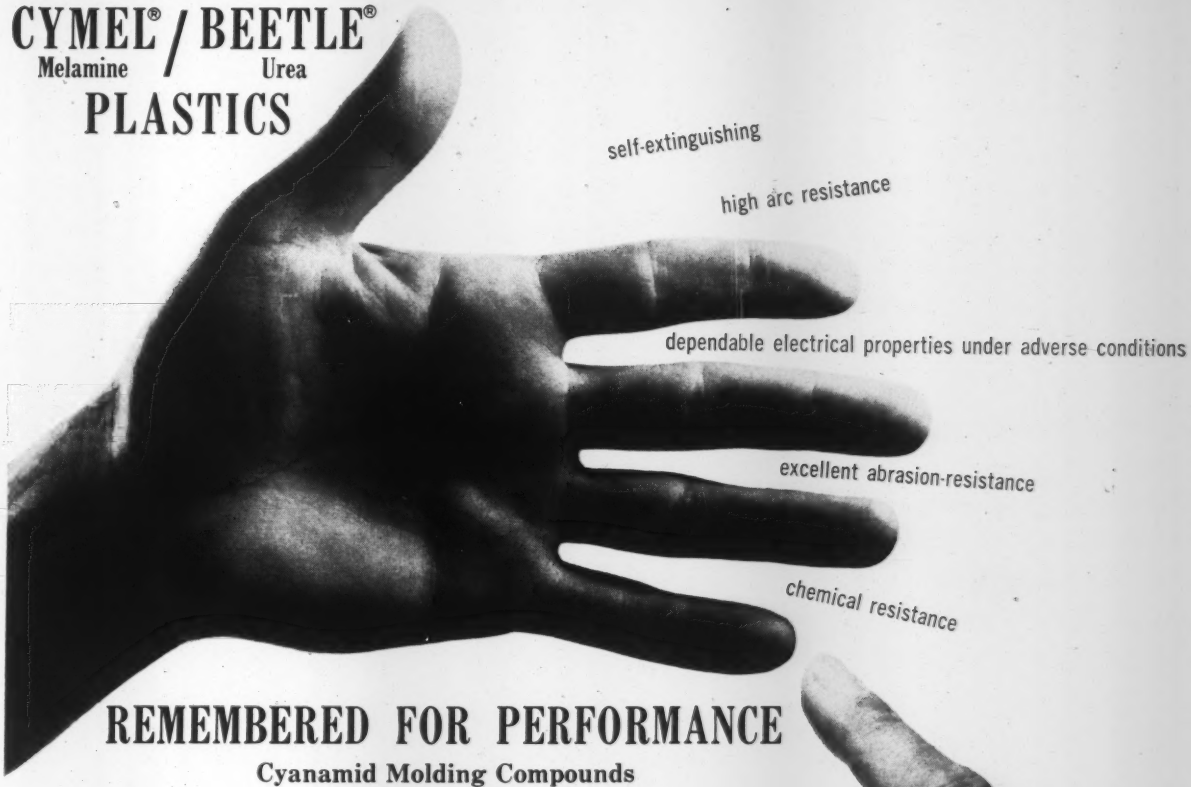

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CYMEL 592 (asbestos-filled) Additional distinctive properties: resistance to atmospheric extremes; high dielectric strength. Typical applications: connector plugs; terminal blocks; a/c, automotive and heavy duty industrial ignition parts. Specifications: MIL-M-14E MME; Federal L-M-181 Type 2; ASTM D704-55T Type 2, SP1 SPEC NO. 27025.

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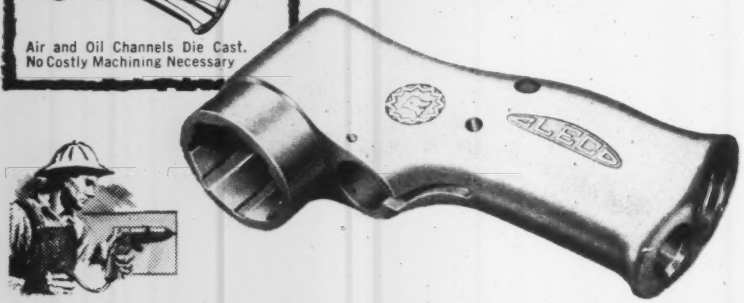

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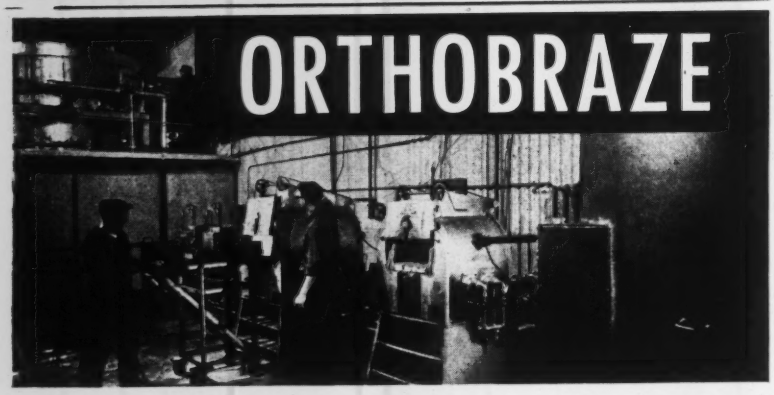

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TECHNICAL LITERATURE

per, zinc, titanium, nickel, beryllium, cobalt and precious metals.

Information on the structure of metals, the solid state, equilibrium diagrams, metal failure, hardening, annealing, heat treatment, casting, powder metallurgy, electroplating, electroforming, machining and finishing.

Properties of Cast Iron at Elevated Temperatures. *ASTM STP No. 248. American Society for Testing Materials, Philadelphia. 1959. Paper, 8½ by 11 in., 95 pp. Price $4.25*

Evaluation of six commercial, low alloy gray irons and one unalloyed ferritic nodular iron at 800 and 1000 F by means of tensile, creep-rupture and thermal shock tests. Both as-cast and annealed structures were investigated.

Books on Paper, Radiation and Fatigue. *American Society for Testing Materials, Philadelphia, 1959. Cloth, 6 by 9 in.*

Symposium on Basic Mechanism of Fatigue. *ASTM Special Technical Publication No. 237. 121 pp. Price $3.75*

The six papers given in this book include: internal friction, plastic strain and fatigue in metals and semiconductors; slipband formation and fatigue cracks under alternating stress; cycle-dependent stress relaxation; and fatigue failure in metals.

Symposium on Paper and Paper Products. *ASTM Special Technical Publication No. 241. 78 pp. Price $2.75*

The seven papers given in this book include: developments in paper testing; developments in the internal bonding of paper; a new cotton paper furnish; Clupak paper (a new type of high stretch paper); and relative humidity measurements in package materials testing.

Symposium on Radiation Effects on Materials: Volume 3. *ASTM Special Technical Publication No. 233. 170 pp. Price $4.25*

The 12 papers given in this book include: a new research reactor for irradiating materials; an integrated facility for study of effects of nuclear radiation on materials; an in-pile fatigue testing apparatus; reactor pressure vessel design for nuclear applications; effects of irradiation on type 346 stainless steel; radiation damage effects on reactor control materials; radiation behavior of fuel materials for sodium graphite reactors; irradiation of uranium fissium alloys and related compositions; effects of nuclear radiation on natural quartz piezoelectric crystals; and effects of high neutron and gamma fluxes on transmission characteristics of some optical glasses.

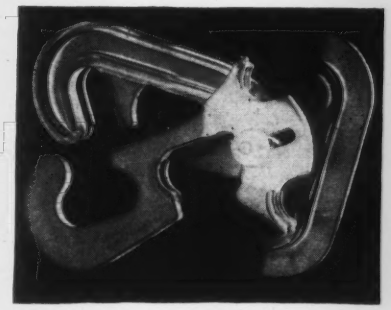
1959 Atomic Industry Directory of Products, Equipment and Services. *Atomic Industrial Forum, New York. 1959. Paper, 5¾ by 8½ in., 130 pp. Price $3.50*

Alphabetical listing of companies and organizations supplying such nuclear products as shielding materials, control materials, cladding and matrix materials, fuel elements irradiated industrial products, lubricants and fuels.

Unfired Pressure Vessels: Section 8 of ASME Boiler and Pressure Vessel Code. *American Society of Mechanical Engineers, New York. 1959. Cloth, 8½ by 11 in., 220 pp. Price $6*

Incorporates all changes that have been made in the ASME boiler and pressure vessel code since 1956. One of the major revisions concerns a ruling on nodular (ductile) cast iron. The book also contains five mandatory appendixes dealing with supple-

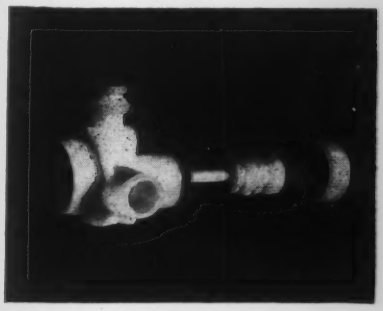
1 Nylon replaces metal in this idling cam. made by Chicago Molded for Holly Carburetor. By injection molding it of nylon, CMPC eliminated 3 operations—hardening, stamping, and assembly . . . cut production costs 50%. A unique mold design provides for easy changes in the number and sizes of ratchets at minimum expense. By any measure of value analysis, this is *designing for profit.* Think how this foresight could benefit your product, your profit.



2 This molded plastic suspension clamp, used for spacing power cables, has installation-ease and maintenance savings designed into its 4 integrated acrylic parts. The two-piece clamp body is fastened securely with a special bolt and nut, also acrylic. Injection molded, the clamp saves up to 60% of the cost of conventional systems—another example of designing for profit with plastics by CMPC.

3 Linear polyethylene replaces brass in this deep-well component injection molded by Chicago Molded for Red Jacket Manufacturing Company. By applying the right plastic material and molding method, CMPC solved a long standing corrosion problem and improved pump efficiency. Cost—a fraction that of brass with finishing eliminated. Perhaps you have a similar part or component.

5 *ways to design for profit with Chicago Molded plastic parts*



4 These injection molded nylon shapes compose a unique Venturi Valve unit used to regenerate the mineral bed of a Culligan Water softener. Previously, they were brass. By switching to Chicago Molded Thermoplastics, performance and durability were improved, material cost cut, machining and finishing eliminated. Your job may be smaller or very large, may require a different plastic, compression or transfer molding. For the right combination, call CMPC.

5 This transfer molded part is one of 10 Tormat memory blocks in the Seeburg Selectomatic 200 phonograph. The Chicago Molded body involves closest tolerances at 10 key spots on each side of the blocks. Fine detail and dimensional stability, good dielectric properties and high moisture resistance were basic material requirements met by CMPC. Our engineers can suggest ways to make your products better by designing in plastics . . . *designing for profit.*

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TECHNICAL LITERATURE

mentary design formulas, definitions and charts. Sixteen non-mandatory appendixes contain information on new materials and suggested good practices. They also give examples illustrating the application of code rules and formulas.

Fabrication of Molybdenum. *American Society for Metals, Cleveland, Ohio. 1959. Paper, 8½ by 11 in., 220 pp. Price $6.50*

Subjects of the 18 papers given in this book include: molybdenum as a structural material; development of molybdenum-base alloys; production of molydenum mill products; welding, brazing and machining of molybdenum; protective coating systems for molybdenum; press extrusion of molybdenum tubing; coating development and evaluation; fabrication of electronic tube components; forging of molybdenum and its alloys; missile structures and power plants; molybdenum requirements in the petrochemical industry; forming of clad molybdenum; and molybdenum requirements in nuclear energy.

Plastics Safety Handbook. *Society of the Plastics Industry, Inc., New York. 1959. Paper, 6 by 9 in., 216 pp. Price $5*

Points out hazards associated with calendaring, coating, casting, compression and transfer molding, extruding, injection molding, laminating, thermal forming and mechanical finishing of plastics products. Discusses fire prevention, health and hygiene, inspection, housekeeping, machinery and maintenance.

Reports

Titanium alloy. THE ALL-BETA TITANIUM ALLOY (Ti-13 V-11 Cr-3 Al). *R. A. Wood and H. R. Ogden. Apr '59. 196 pp. Defense Metals Information Center, Battelle Memorial Institute, Columbus, Ohio. (No. 110)*

Summarizes information available on the metallurgy, properties and fabrication of a new type of commercial titanium alloy. This alloy contains about 26% of alloying elements (13 V-11 Cr-3 Al) and has a body-centered-cubic beta phase structure in the annealed condition.

Conductivity of lubricants THERMAL CONDUCTIVITY OF LUBRICATING OILS AND HYDRAULIC FLUIDS. *D. W. McCready, University of Michigan Research Institute. Mar '59. 59 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1.50 (PB 151780)*

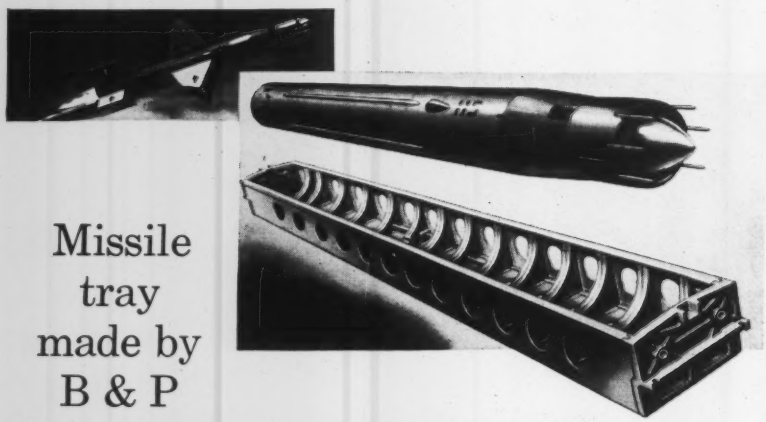
Study of the thermal conductivity of 40 natural and synthetic-base lubricating fluids. Thermal conductivity values in the temperature range 70 to 500 F are reported for fluids considered stable to 500 F.

Standards for aluminum conductors *1959. American Standards Assn., 70 E. 45th St., New York 17.*

RECOMMENDATION FOR AN INTERNATIONAL SPECIFICATION FOR ALUMINUM ALLOY CONDUCTOR WIRE OF THE ALUMINUM-MAGNESIUM-SILICON TYPE *Price 60¢ (No. 104)*

RECOMMENDATION FOR COMMERCIAL-PURITY ALUMINUM BUSBAR MATERIAL. *Price 60¢ (No. 105)*

Properties of stainless steels PHYSICAL AND MECHANICAL PROPERTIES OF NINE COMMERCIAL PRECIPITATION-HARDENABLE STAINLESS STEELS. *D. A. Roberts, D. B. Roach and A. M. Hall, Battelle Memorial Institute, Defense Metals Information Center. May*



Missile tray made by B & P

beats target weight by 300 lbs.

Air transported missiles require minimum weight handling equipment so that important defense weapons can be moved efficiently and on schedule. Recently, Brooks & Perkins was given the responsibility for engineering, designing, building the prototype and manufacturing an aluminum missile tray, shown above.

Unusual loading problems and the extreme importance of deflection required a dimensional tolerance of ± 1/32" in the 33-foot over-all length at 68°F. B & P not only met all tolerance requirements, but also reduced the initial target weight by 300 lbs.

The aluminum missile tray is another example of Brooks & Perkins skill and experience in the fabrication of light metal products for ground support equipment.

For more information and details of this and other GSE programs, write direct to Brooks & Perkins, Detroit.

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ASBESTOS:

Its Industrial Applications

by D. V. ROSATO

Assistant Plant Manager
Research Division, Plastics Plant
Raytheon Manufacturing Co.

1959, 224 pages, $5.75

The author compiles and presents all available data on the properties and applications of asbestos, including recent advances. The book identifies the broad usage of asbestos in many engineered products. It serves as a convenient guide to various branches of industry including research and development groups, manufacturers, engineering schools, market research groups, and sales management. In addition to acquainting industry with asbestos products in a great variety of fields, the book also reviews the types of asbestos material available, their properties, and methods of manufacturing to further the understanding of the variables which exist in handling asbestos.

CONTENTS: Industrial Applications of Asbestos; Properties of Asbestos; Asbestos-Cement; Tile; Asbestos Heat Insulation; Asbestos Electrical Insulation; Asbestos Friction Materials; Asbestos Textiles; Plastics; Asbestos Packings and Gaskets; Asbestos Filters; Other Products; Census on Asbestos Products; Bibliography; Index.

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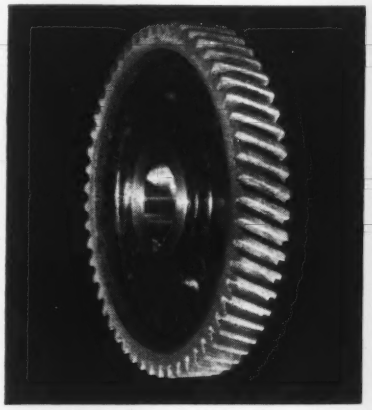

Strength. Stamina is built into every CDF Celoron gear. Stronger teeth, longer running life, and smoother performance are characteristics of the Celoron gear. No type of "cheaper" gear construction has yet proved as satisfactory.

What it is. Each CDF Celoron gear blank is molded of laminated and macerated cotton cloth impregnated with a special phenolic resin. Gear teeth are cut in the laminated rim. Repeated tests prove the high impact strength, the great wear-resistance, and the low tone frequency of this "silent" gear material.

Design and purchasing men interested in adapting Celoron gears for engine-timing and other needs may obtain full technical data (properties, horsepower ratings, etc.) by writing to the Celoron Division of CDF at Bridgeport, Pennsylvania.

COMPLICATED PLASTICS PARTS AT LOW COST THROUGH POSTFORMING CDF DILECTO

How it's done. Briefly, postforming is effected by heating a special grade of CDF Dilecto® laminated plastics until it's pliable, and then forming it in an unheated, inexpensive mold.

Less expensive. When you postform Dilecto parts, you generally save money all around: Lower die costs (often wood or plastics is entirely satisfactory); lower retooling costs to meet new specifications; lower labor costs—these are a few of the savings made possible through postforming of Dilecto.

Why Dilecto? Where you need high strength-to-weight ratio, superior electrical and chemical properties, light weight, easy machinability, and excellent resistance to abrasion, weathering, and moisture—CDF Dilecto laminated plastics give you the best combination. CDF delivers either the Dilecto stock or the completely fabricated parts as specified.

Special Dilecto grades. For better response to severe bends and deep draws, and for the ability to take the most involved forming without fracturing, choose one of the special postforming grades of Dilecto, described in CDF Technical Bulletins 11,110 and 11,140. Most of the standard Dilecto grades, though, can be postformed to some degree.

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NEW CDF LITERATURE • *For Bulletins referred to in this advertisement, or for recommendations relating to your current problem in electrical insulation, send this coupon.*

Please send the following Technical Bulletin(s):*

☐ Celoron Molded Gears, Bulletin C-58

☐ Dilecto Postforming Grades, Bulletins 11,110 and 11,140

☐ Please have a CDF representative call to discuss my electrical-insulation problems in detail.

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Dielectric Strength S/S Parallel To Lamination	A D-48/50	Min. KV.	60.0 15.0	80.0 40.0
Dissipation Factor	A D-24/23 D-48/50	Max. 10 Cycles	0.035 0.035 0.05	0.028 0.035 0.038
Insulation Resistance	C-96/35/90	Meg.		50,000
MECHANICAL				
Impact Strength IZOD - Edgewise	E-48/50	Min. Ft. Lb. Per Inch of Notch L C	0.35 0.30	2.30 1.40
Flexural Strength Flatwise	A	Min. L P.S.I. C	12,000 12,000	16,000 14,000
Hot Solder	A		580°F - 7 Sec.	No Blister

PLASTICS DIVISION FARLEY & LOETSCHER MFG. CO. DUBUQUE, IOWA

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TECHNICAL LITERATURE

'59. 70 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. (PB 151068)

Physical and mechanical properties of two martensitic types (W and 17-4 PH), four semi-austenitic types (17-7 PH, PH 15-7 Mo, AM 350 and AM 355) and three austenitic types (A-286, 17-10 P and HNM) of stainless steel.

Safe handling of zirconium *1959. 16 pp. National Fire Protection Assn., 60 Batterymarch St., Boston 10. Price 50¢ (No. 482M)*

Tells how to prevent fires and explosions when handling zirconium.

Protective coatings for molybdenum COATINGS FOR PROTECTING MOLYBDENUM FROM OXIDATION AT ELEVATED TEMPERATURES. *E. S. Bartlett, H. R. Ogden and R. I. Jaffee, Defense Metals Information Center, Battelle Memorial Institute. Mar '59. 45 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1.25 (PB 151064)*

Advantages and disadvantages of chromium, silicon, nickel, precious metal, ceramic and refractory oxide coatings for protecting molybdenum against oxidation at high temperatures. The protective coatings are presented from two points of view: the coating systems and the methods of application. Methods of application include electroplating, flame spraying, vapor deposition, cladding, enameling and liquid-phase diffusion.

Oxidation of sheet alloys OXIDATION OF EXPERIMENTAL ALLOYS. *J. C. Richmond and H. R. Thornton, National Bureau of Standards. Feb '59. 19 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price 50¢ (PB 151741)*

Information on the oxidation resistance of five new high temperature sheet alloys —two nickel-molybdenum-chromium alloys and three iron-chromium-aluminum alloys.

Product development A MODERN DYNAMIC APPROACH TO PRODUCT DEVELOPMENT. *Sidney Sobelman, Picatinny Arsenal, 1959. 205 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $3.50 (PB 151649)*

Shows how to conserve time and money in developing a new product.

Corrosion prevention CORROSION PREVENTION. *Office of the Chief of Civil Engineers, Bureau of Yards and Docks, U. S. Navy. Dec '58. 431 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $6 (PB 151756)*

Data are given for atmospheric, submerged and subsurface corrosion, and corrosion on areas alternately wet and dry. Corrosion processes discussed include those caused by the use of dissimilar metals, with particular emphasis on the electromotive force series and galvanic corrosion, direct chemical attack, stray currents, microbiological and atmospheric attack, and marine corrosion. Discusses such corrosion control methods as coatings, claddings and coverings.

Columbium-base alloys DEVELOPMENT OF NIOBIUM-BASE ALLOYS. *R. T. Begley, Westinghouse Electric Corp. Mar '59. 192 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $3 (PB 151739)*

Study of the creep-rupture properties, flow and fracture characteristics, oxidation behavior, and weldability of columbium-base alloys. An electron-beam-melted columbium-base alloy showed much lower rupture strength than a powder-metallurgy columbium containing 0.6% zinc.

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Second of a series

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says W. M. Robertson
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"THERE'S a bright new future for pressure packaging now that it's practical to use plastic-coated glass," continues Mr. W. M. Robertson. "Glass is flavorless, odorless and impervious to chemicals. And its moldability gives the designer new opportunities to create beautiful and unusual container shapes.

"The new Owens-Illinois line of glass pressure packages was made possible by *Chem-o-sol*, the plastic coating which we bond to the surface of glass containers. We bond it so well, in fact, that the coating becomes an integral part of the package. *Chem-o-sol* not only gives the protection the bottles need, but it provides attractive color and an outer surface that is warm to the touch. Our production people tell me that *Chem-o-sol*, being a liquid, is easy to handle and apply.

"Developing the new Owens-Illinois line was a major project. The research and development people of Chemical Products Corporation worked with our technical staff to develop the best formulation and application methods. Their ability to give us the colors we wanted, a uniform product, and deliveries on schedule helped keep the project moving. We also like the way they continue to be interested in improving our *Chem-o-sol*-coated glass containers and the methods we use to make them."

Learn more about this organization and its capacity for research and development. And about *Chem-o-sol* — a material with the unique ability to transform existing products into something new and better. Write for our brochure "Chem-o-sol — Going Plastisols One Better." **Chemical Products Corporation, East Providence, Rhode Island.**

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HIGH STRENGTH—HIGH TEMPERATURE PHENOLIC MOLDING COMPOUNDS solve many missile problems for Aerojet-General where high temperature insulation with good strength-to-weight ratio is required.

For information about how Trevarno Resin Pre-Impregnated Glass Fabric can help you solve your problems, write or call District Office nearest you.

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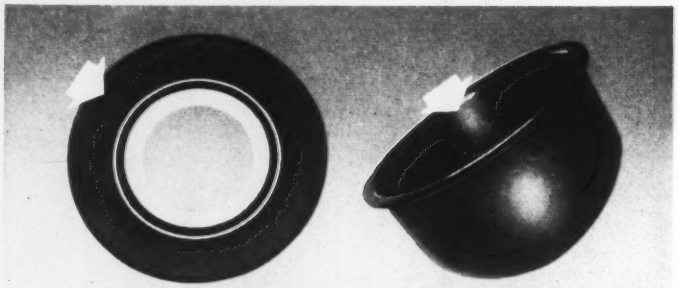
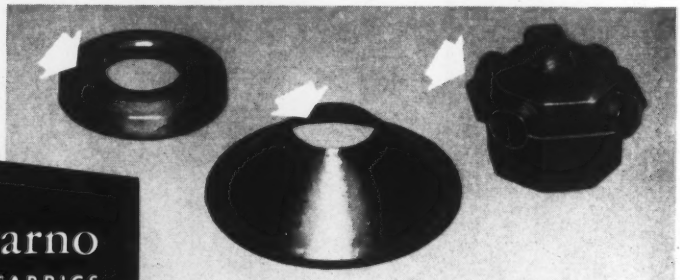
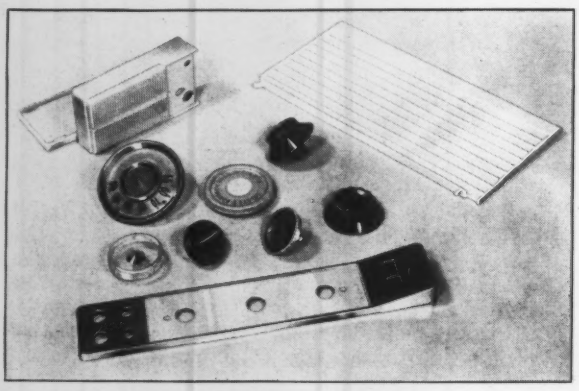
Trevarno
GLASS FABRICS



Ease of fabrication, both in time and labor required, lower cost of tooling, high glass content, give these parts their strength-to-weight ratio.



Trevarno high strength, high temperature phenolic glass molding compounds are used extensively where housing for electrical components are required because of its excellent insulating properties.



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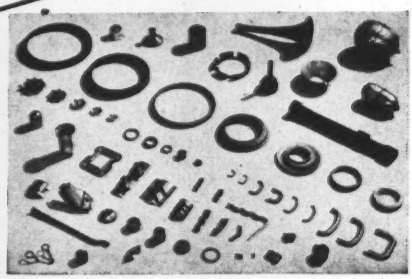

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Operating 50 pieces of production equipment to blank, pierce, form, draw, swedge, coin, drill, tap, heat treat, anneal, silver braze, test and assemble. Complete tool room facilities for producing all dies. Modern inspection equipment assures quality control.
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M&T

News about COATINGS FOR METALS

from Metal & Thermit Corporation

Textured vinyl finishes now produced with sprayed coatings

To get a textured vinyl finish, designers are no longer restricted to laminated types. Two recent M&T developments in *sprayed* vinyl coatings make such appealing finishes especially easy to adopt. Actually, they *widen* the variety of patterns practical for metal panels, cases, housings and other parts.

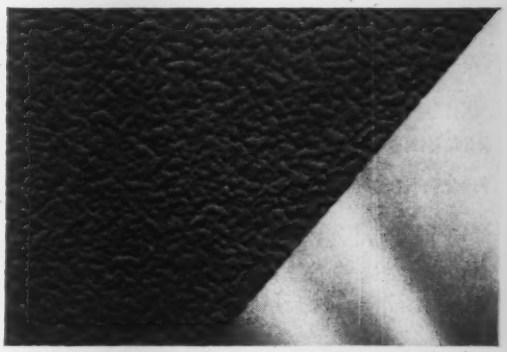
TWO WAYS TO FINISH

Texture is produced chemically with *Unichrome Coating 6400*. Sprayed on smooth metal sheets and shapes, this coating gives a handsomely textured finish with warmth and leather-like appearance.

Unichrome Coating 6440 was developed for use on mill-patterned steel or aluminum, now becoming available in an increasing number of extremely attractive patterns. This coating does not alter the profile of the pattern. Whether applied thick or thin, it will faithfully mirror even the most delicate design rolled into the metal.

EXCEPTIONAL DURABILITY

Both of these sprayed vinyl coatings prove up to ten times more wear resistant than the usual baked textured enamel. In a recent evaluation for food shelves, M&T's *Coating 6400* withstood a half million "rubs" from canned goods and still looked new; the shelf with baked enamel showed wear after only 30,000 abrading strokes from the can.



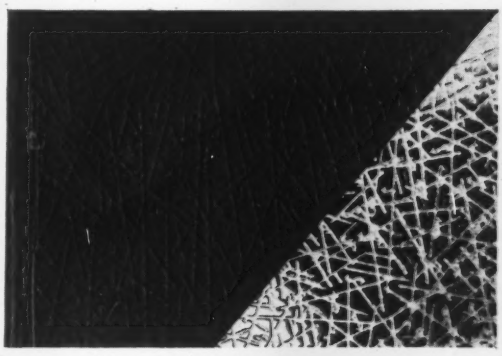
Unichrome Coating 6400 sprayed on smooth metal develops a texture with the appearance of luxurious grained leather.

The inherent chemical resistance in these vinyl coatings also protects against stains and corrosion. Their insulating qualities mean warmth to the touch, and also aid in sound-deadening.

As for production benefits, the sprayed finish eliminates the expensive scrap loss incurred with laminates; it also eliminates seam problems at joints.

For more details, write METAL & THERMIT CORPORATION, Rahway, N. J.

Unichrome Coating 6440, whether sprayed thick or thin, produces an exact replica of the metal pattern beneath it; also contributes warmth, color, and unusual protection.



M&T **coatings and finishes**

METAL & THERMIT CORPORATION

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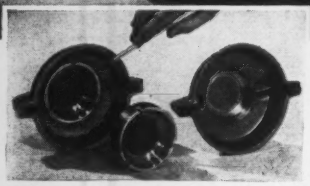
THIS CAPS IT!



COSTS 25% LESS, WEIGHS 25% LESS, MEETS EVERY SERVICE REQUIREMENT, LOOKS BETTER, AND DOESN'T REQUIRE ANY FINISHING!

This is a "spin-cap", used on Lindsay Water Softeners. It used to be made of brass, like the one at left, above. We now make it of nylon-reinforced premix plastic as shown at right, above.

We suggested the design, and even though we're plastics people, recommended that the brass threads be retained. (Salt used in the water-softener *could* cause mechanical binding of plastic threads.) The threaded brass insert, also our design, (see small photo above) is molded integrally with the cap, to solve that. Tooling required about one-half the time required to tool up for casting.

The big point is, Lindsay Company and their customers are benefiting from a *practical* improvement — *and* saving money!

NOTE: We regularly mail case histories showing new things we're doing with reinforced plastics. If you'd like copies just jot your name and address on this coupon and mail it to us.

You can, too. Send us drawings, photos, or sketches, and tell us what you want to do. We'll tell you, frankly, what is possible and practical . . . help you engineer it . . . and produce it for you!

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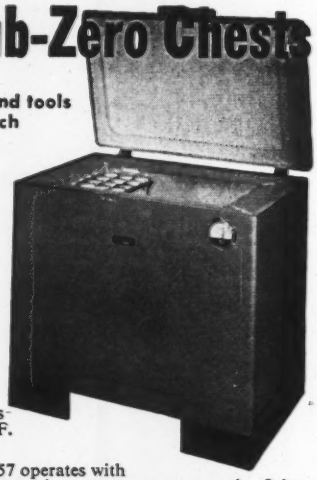

Model RSZ503 Rivet Cooler (shown) equipped with 90 rivet canisters, temperatures to –30° F. 110V, 60 cycle, single phase.

Model SZH153 with temperatures to –95° F. 110V; 60 cycle, single phase.

Model SZH653, larger capacity, temperatures to –85° F. 110V, 60 cycle, single phase.

Model SZHC657. Same capacity as SZH653 but attains temperature as low as –140° F. 220V, 60 cycle, single phase.

Refrigeration: Model SZHC657 operates with 3 Tecumseh hermetic compressors in a two system cascade. Other Sub-Zeros use 2 hermetics in a two stage system. Rivet Cooler operates with single hermetic unit. All models equipped with efficient fan-cooled condensers — no liquid coolant required. *Write Today for Full Specifications and Prices.*

Description	Model	Cu.Ft.	Temp. Range		Outside Dim.			Inside Dim.		
			Rm. 70°	Rm. 110°	L	W	H	L	W	H
Sub-Zero	SZH153	1.5	–95° F.	–85° F.	42″	28″	42¾″	23″	9″	12½″
Sub-Zero	SZH653	6.5	–85° F.	–75° F.	60″	28″	42¾″	47″	15″	16″
Sub-Zero	SZHC657	6.5	–140° F.	–125° F.	60″	28″	42¾″	47″	15″	16″
Rivet Cooler	RSZ503	5.0	–30° F.	–20° F.	42″	28″	41″	30″	16″	18″

REVCO, Inc.

Setting Trends in Refrigeration since 1938 Deerfield, Michigan

APPLIANCE DESIGNERS

Product design and development engineers are needed to help create a new line of household electrical appliances.

Mechanical or electrical engineering training is desirable, plus experience in design and development of consumer electrical appliances or in allied fields. Applicants should have a good working knowledge of materials, underwriter's requirements, heating devices, temperature controls, manufacturing methods and costs.

Most important to success is creative ability and initiative. Advancement is limited only by ability and performance in a company known for its pioneering research achievements for more than 100 years.

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Mr. James L. Knapp

Staff Manager, Research and Development Div.

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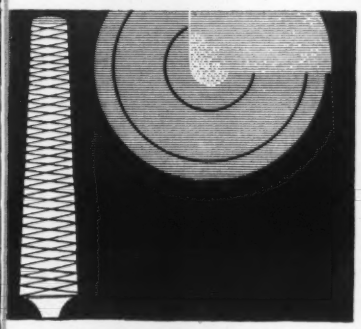
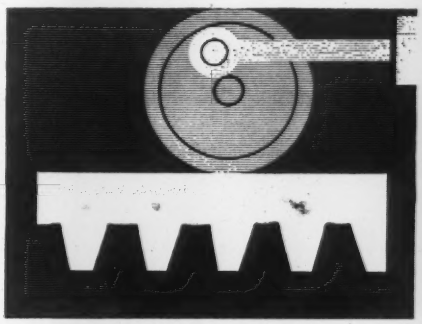


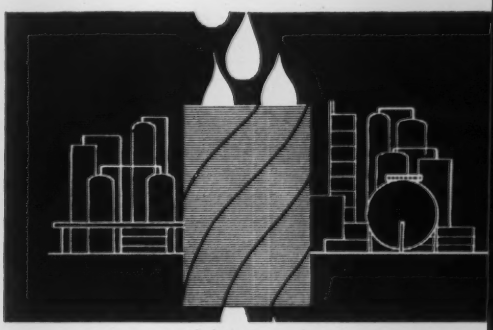
wear resistance

combination of high tensile strength, abrasion tance and tear strength results in long service for parts cast of urethane elastomers.



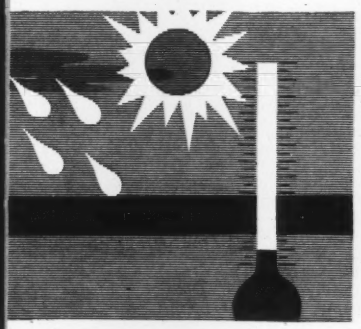
controlled friction

Urethane elastomers have a high coefficient of friction ideal for drive units, or can be modified to be self-lubricating.



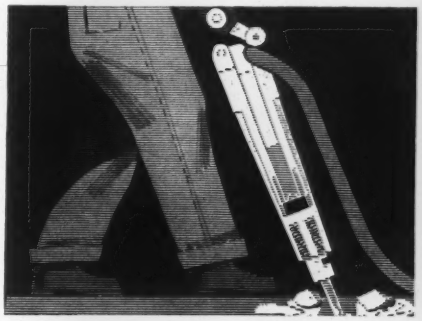
solvent resistance

Urethane elastomers have superior solvent resistance. Oil immersion at 130°C for 100 hours shows little loss of properties.



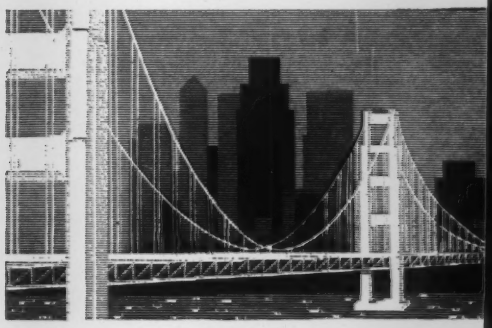
aging resistance

hane elastomers have excellent resistance to ne, oxygen and weathering for longer service.



shock absorption

Urethane elastomers are unique in their combination of high load-bearing, vibration dampening and shock absorbing properties. Rebound elasticity ranges from 45% to 60%.



hardness with elasticity

Properties of high hardness, with high flexibility enable urethane elastomers to "bridge" a basic material gap between metals and rubbers.

Urethane elastomers offer opportunities to build into new or existing products a combination of desirable properties never before possible with a single material.

Urethane elastomers with a hardness range of 60 to 100 Shore "A" durometer, are tough yet elastic, have excellent tensile strength, high resistance to abrasion and oxidation. Softer grades exceed the strength characteristics of natural and synthetic rubbers; while harder urethane elastomers provide a structural and engineering material which combines high hardness and elasticity with other controlled properties, including high or low coefficient of friction.

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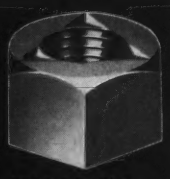

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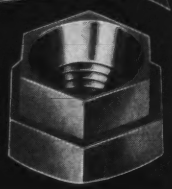

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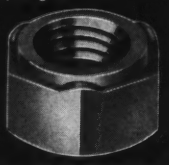

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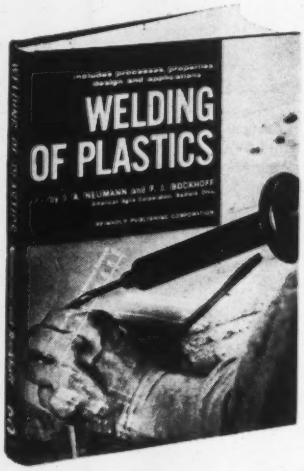

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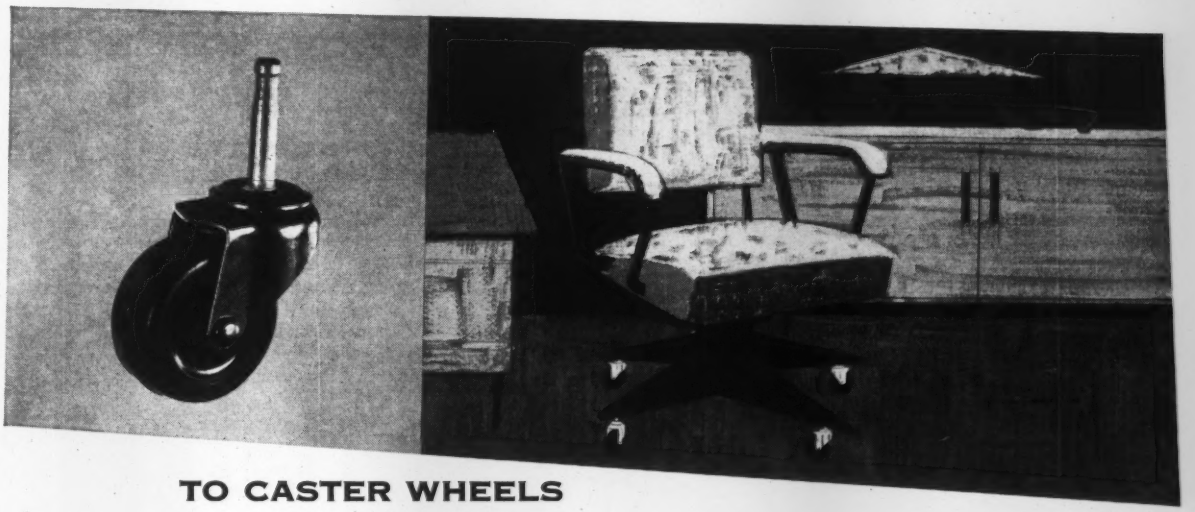

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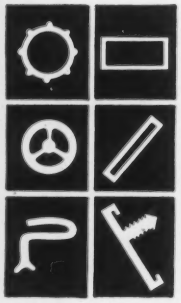

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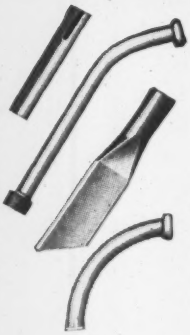

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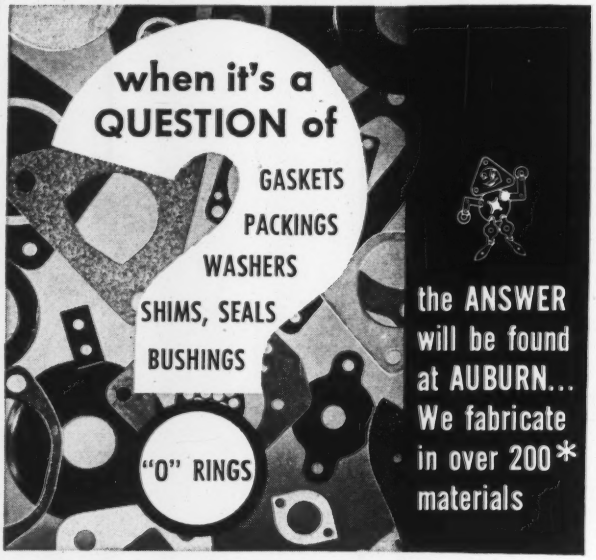

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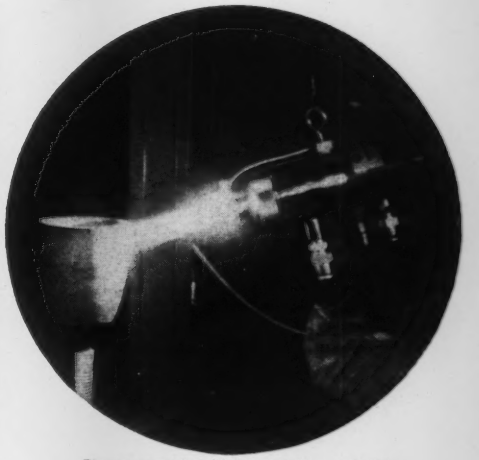

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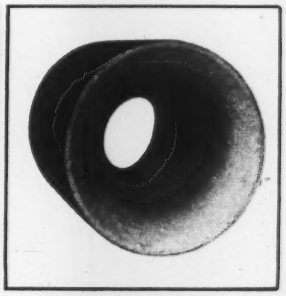

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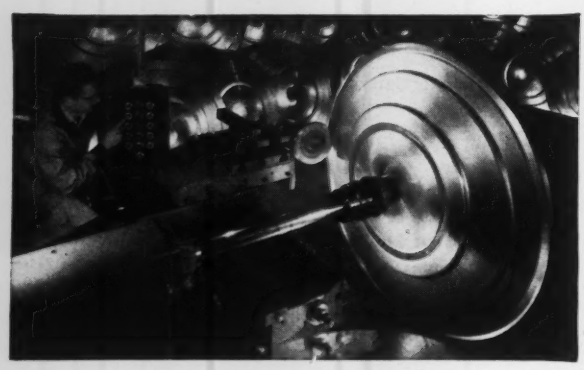

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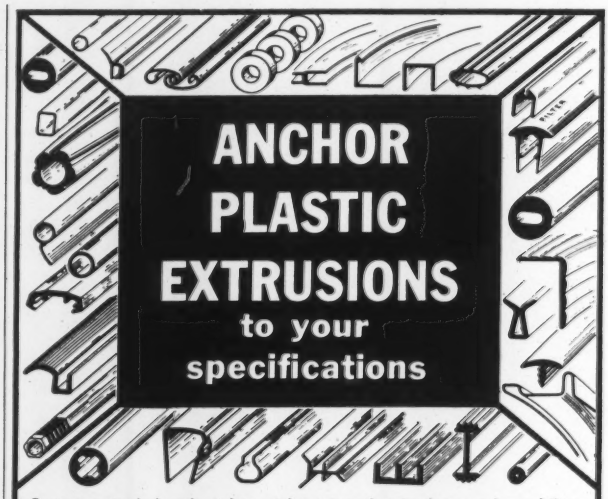

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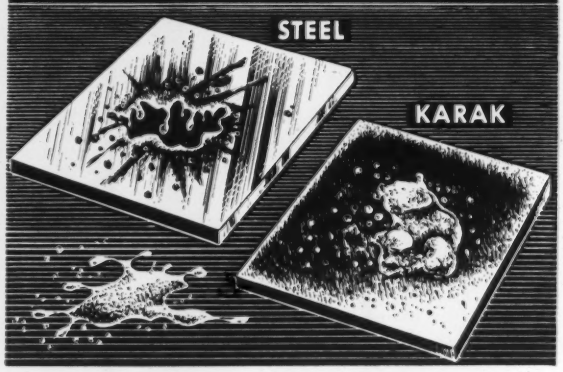

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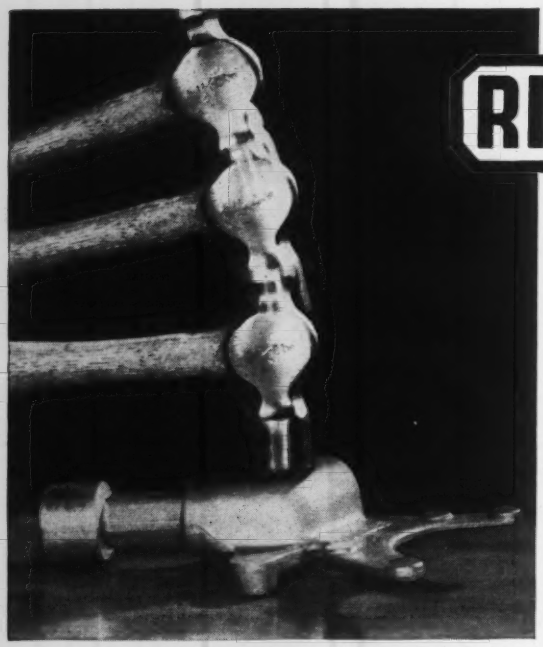

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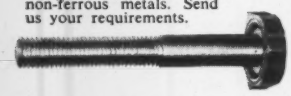

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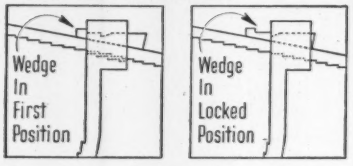

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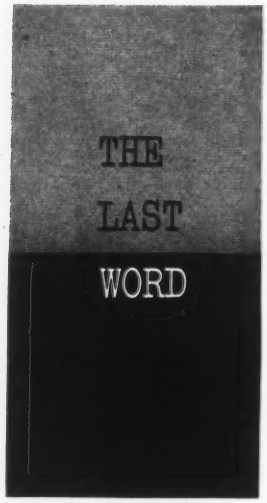

Group Research: A Solution for Small Companies

by H. R. Clauser
Editor

Basic research in industry has become almost an indispensable activity for an increasing number of companies. In some companies it is a requirement for healthy growth; in others it is even necessary for survival.

Research is expensive

But research today is big business, and it is so expensive that only large companies can afford it. According to a study made by J. C. Fisher of the General Electric Research Laboratory, about two-thirds of all basic research is performed by only 59 companies; and, except for pharmaceutical houses, most of these companies have over 5000 employees. In addition, the study shows that only companies of rather wide diversification can economically justify the high cost of an integrated basic research program.

Thus, for many small and medium-size companies, how to get the benefits from the research they need but cannot afford is a serious problem.

Problem serious for small companies

What can the small companies do about it? In many cases they can only hope and wait for the larger companies to do the needed research. Often, though, work on industry-wide problems needing to be researched is sidetracked by problems of more proprietary interest. The smaller companies, of course, can and do make use of the independent laboratories and universities. But, here again, for economic reasons these research efforts must be small, and the programs must usually be restricted to specific problems either of immediate concern or of a proprietary nature. Thus, many basic problems whose solution would help the small company as well as all of the industry remain unsolved until the large companies see fit to tackle them.

The solution: group effort

A growing number of people believe that the solution to the problem lies in cooperative group action. Some trade associations are now sponsoring research projects. The property data center at Purdue, described two months ago in this column, is another example of the group approach. And now there is considerable agitation in the plastics industry for the establishment of an "American Plastics Institute" which would perform research for the benefit of all.

Typical projects which such a research center would undertake are 1) fundamental studies of polymers to determine relationships between structure and properties, and 2) studies to improve our understanding of the processing and fabricating characteristics of plastics. Applied research would also be undertaken. For example, all known instrumentation for measuring the parameters of polymers would be evaluated. Improved instrumentation and methods would help clarify and reduce the large number of physical characteristics now needed by engineers in both the processing and use of plastics.

Committee seeks your help

A committee representing various segments of the industry has been organized to actively seek the views and support of all companies and individuals concerned with the production and use of plastics materials. They want your help and suggestions. So let them know what you think. Write to us, or pass on your views to your own society.

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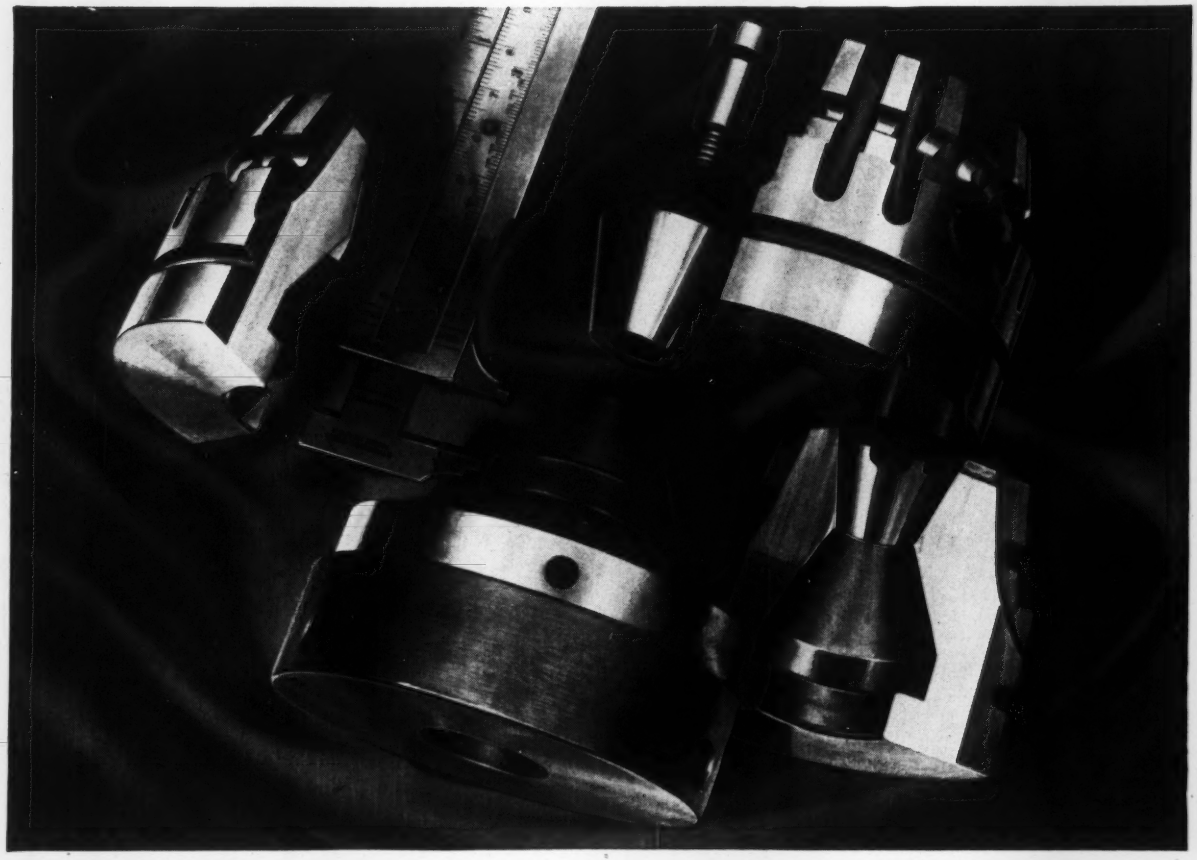

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